State of California
California Environmental Protection Agency

AIR RESOURCES BOARD

PRELIMINARY DRAFT STAFF REPORT

MAY 31 WORKSHOP
ZEV 2000 BIENNIAL REVIEW

MAJOR CHANGES FROM THE MARCH 29 WORKSHOP VERSION

This document is a revised and expanded version of the Revised Preliminary Staff Assessment that was released prior to the March 29 ZEV 2000 Biennial Review workshop. This version has been updated and revised in response to public comments received. In addition, there are more complete discussions of cost, and the EV market.

Please note that a revised version of the former Emission Benefit section is still under development and will be released separately. That section has been renamed Environmental and Energy Impacts, to highlight the fact that ZEVs have benefits beyond our traditional focus on urban air quality improvement.

Significant changes in this document are as follows:

- The Introduction now contains a new section 1.7, Public Comments, that summarizes the major themes expressed in public comments to date.
- The Introduction also contains a new section 1.4, Progress Since the Last Biennial Review, that highlights noteworthy recent developments.
- The Cost Estimation Methodology section now describes staff methodology for comparing the cost of various near term vehicle types.
- The EV Market section contains extensive additional discussion.
- The Conclusion section now contains a new section 10.2 entitled Blueprint for Further Progress.
- The release date for the Staff Report has been moved from late July to early August.

There are also other minor updates throughout the body of the report.

EXECUTIVE SUMMARY

The Air Resources Board's Zero Emission Vehicle (ZEV) program was originally adopted in 1990, as part of the first Low-Emission Vehicle regulations. The ZEV program is an integral part of California's mobile source control efforts, and is intended to create a market for advanced technologies that will secure maximum air quality benefits for California now and into the future.

Continued reliance on today's technology will not allow California to reach its health-based air quality goals. In ARB's vision of the future, therefore, the vehicle fleet will produce zero tailpipe emissions, and will use fuels with minimal "fuel cycle" emissions (emissions that occur due to vehicle refueling and the related production or transportation of fuel). Among the auto manufacturers, there is a general consensus that global customer demands will reward companies that can meet society's transportation needs while eliminating harmful environmental impacts. Thus, although there may be disagreements over the pace of change and the path to be followed, the ultimate goal is not in question.

Pure zero-emission vehicles hold distinct air quality advantages over technologies that use a conventional fuel such as gasoline in a combustion engine. Vehicles with combustion engines inevitably exhibit deterioration that results in increased emission levels as the vehicle ages. They are also subject to becoming gross polluters if critical emission control systems fail. High volatility liquid fuels such as gasoline are responsible for significant fuel cycle emissions. For all of these reasons, vehicles with no potential to produce emissions are the "gold standard" of even the cleanest, most advanced new technologies.

When the ZEV requirement was adopted in 1990, low- and zero-emission vehicle technology was in a very early stage of development. The Board acknowledged that many issues would need to be addressed throughout the program's implementation. Thus the Board directed staff to provide an update on the ZEV program on a biennial basis, in order to provide a context for the necessary policy discussion and deliberation. The next biennial review of the ZEV program is scheduled for September 7th, 2000.

The Board last conducted a Biennial Review of the ZEV program in 1998. Since that time, electric vehicles (EVs) have rapidly moved into widespread real world applications.

In preparing for the Board's upcoming Biennial Review, the goal of the staff is to provide a thorough, accurate portrayal of the current status of ZEV technology and the prospects for improvement in the near- and long-term. The purpose of this document is to put forth technical information for public review and comment, develop a framework and context for consideration of the relevant issues, and provide an opportunity for interested parties to point out errors, omissions, or

other problems in the factual basis that will be made available to the Board. Comments are welcome on all aspects of this material.
Considerable public comment was provided at the initial March 29 public workshop and in separate written submittals. Major themes addressed by commenters included ARB's leadership role, comprehensive environmental and energy impacts of the ZEV program, unmet current demand for vehicles, the EV lease process, vehicle performance, real vs. perceived range needs, the cost of additional range, lifecycle cost, automaker experiences to date, and recommended changes to the regulation.

Manufacturer Status

The ZEV requirement applies to large and intermediate volume manufacturers. Beginning in model year (MY) 2003, at least 10 percent of the passenger cars and light duty trucks produced and delivered for sale in California by large and intermediate volume manufacturers must be ZEVs. An intermediate volume manufacturer may meet this ZEV requirement entirely with partial ZEV allowance vehicles. A large volume manufacturer must meet at least 40 percent of its ZEV requirement with pure ZEVs or full ZEV allowance vehicles. Large volume manufacturers may, at their option, meet the remaining 60 percent of their ZEV requirement with partial ZEV allowance vehicles.

Because model year (MY) 2003 is quickly approaching and planning for MY 2003 production is well underway, ARB staff has attempted to establish each manufacturer's volume classification and, thus, each manufacturer's ZEV requirement. Based on current production and sales data, ARB staff expects the small volume manufacturers in MY 2003 to be Porsche, Saab, GFI, Ferrari, Dae Woo Motor Company, Rolls Royce, Suzuki, Lamborghini and Lotus. Based on the same data, ARB staff expects the intermediate volume manufacturers in MY 2003 to be BMW, Subaru (Fuji), Hyundai, Isuzu, Jaguar, Kia, Mazda, Mitsubishi, Rover, Volkswagen and Volvo. ARB staff expects the large manufacturers in MY 2003 to be DaimlerChrysler, Ford, GM, Honda, Nissan and Toyota.

In recent years there have been many new multi-manufacturer arrangements, which have made it difficult to delineate individual companies. To clarify the ZEV-related emission compliance liabilities of companies in multi-manufacturer arrangements, ARB staff held a workshop on March 30, 2000. Manufacturers are currently reviewing the implications of using the CAP2000 aggregation provisions for this purpose and are also developing, for further discussion and consideration, criteria to better specify the current definition of operational independence.

In rough terms, each one percent of California light-duty vehicle sales equals about ten thousand vehicles per year. The calculation of the actual number of vehicles needed to meet the ZEV requirement in any given year, however, is considerably more complex. To provide a context for the Board's evaluation of the ZEV program, staff have developed a "base case" estimate of the number of ZEVs that the large manufacturers must produce in 2003 in order to satisfy a four percent ZEV requirement. Due to trade secret considerations, this estimate does not rely on any confidential information provided in the manufacturer product plans. Assuming that the vehicles used to meet the requirement have the same range as the vehicles available today, staff estimates that roughly 22,000 zero emission vehicles would need to be produced in 2003. This corresponds to about 2.3 percent of the passenger car and light duty truck production of the affected manufacturers. It must be noted, however, that actual 2003 ZEV production may vary significantly from this number.

All manufacturers have indicated that they have the technical capability to produce the quantity of vehicles needed to meet their 2003 obligation. The manufacturers uniformly argued, however, that the cost of these vehicles remains high, and foreseeable battery technology will result in limitations on vehicle range. Thus in their view it will be very difficult to develop a self-sustaining mass market for battery electric vehicles at this time.

Staff notes that technical advances are steadily reducing the cost premium associated with ZEVs and that increased production volume will bring about further reductions.

Compliance with the Memoranda of Agreement

In 1996, the Executive Officer of the Air Resources Board and all large auto manufacturers signed Memoranda of Agreement (MOAs). The MOAs are intended to ensure the successful introduction of zero emission vehicles into the marketplace. They include numerous binding commitments from each of the auto manufacturers as well as from ARB. Staff concludes that the manufacturers and the ARB have met their current commitments in the MOAs. As part of the state's efforts, the ARB and the Department of General Services have undertaken a number of activities designed to facilitate leasing of ZEVs. Such efforts include the EV Loan Program, the ***ev Sacramento*** Program, the EV Rental Demonstration Program, the EV Long Term Placement Program, and outreach by the Office of Fleet Administration.

Vehicle Technology Assessment

In June 1999, ARB began meeting with auto manufacturers to discuss their obligations and plans for meeting the ZEV requirement in MY 2003. In December 1999 and February 2000, ARB staff visited all the large volume manufacturers in Japan and in the United States to examine, first hand, the progress each manufacturer is making in preparing to meet the ZEV requirement.

From the inception of the ZEV program, the battery electric vehicle has been the leading candidate for meeting the ZEV percentage requirements due to its stage of commercial development. Since 1990, worldwide effort in the research and development of vehicle and battery technology has greatly improved the prospects for the successful commercialization of electric vehicles. More recently, fuel cell technology has gained worldwide attention as a technology capable of supplanting current internal combustion engine vehicles in the market while providing zero direct emissions (when using stored hydrogen).

In 1998 the ARB modified the ZEV requirement to allow ZEV credit to be earned by vehicles with near-zero emissions, referred to as "partial ZEVs" (PZEVs). Staff believes that this partial allowance approach towards satisfying the ZEV requirement will promote the continued development of battery-powered electric and zero-emitting fuel cell vehicles, while encouraging the development of other advanced technology vehicles that have the potential for producing extremely low emissions. At the present time, only the Nissan Sentra 'CA' ("Clean Air") has achieved California certification for PZEV credit. Several other vehicles have achieved Super Ultra Low Emission Vehicle (SULEV) level exhaust emissions, but have not yet demonstrated compliance with the full set of PZEV requirements. Great progress has also been made on the development of gasoline-electric hybrid vehicles. Based on public announcements to date, however, staff does not believe that grid-charged hybrid-electric capability will be made available on any MY 2000-2003 vehicles.

Several classes of small on-road electric vehicles have begun to emerge in the last few years that will displace gasoline vehicle usage and increase overall zero-emission miles traveled within California. Examples of such vehicles include low speed neighborhood electric vehicles (NEVs/LSVs), and city electric vehicles (City EVs). These vehicles are under consideration because they offer a number of desirable characteristics, including very high efficiency, affordability, the potential for reduced congestion, and many niche market applications. Under current state law and ARB regulation, NEV/LSVs and City EVs all qualify as "passenger cars" and therefore are eligible to earn full ZEV allowances. In terms of trip replacement and the resulting air quality impact, however, these vehicles differ, and are not the complete equivalent of full-range EVs. Therefore it is not clear that they should all be treated the same. ARB staff plan to evaluate the relative emissions benefit of the various categories of vehicles.

Battery Technology Assessment

The cost of batteries, both today and when produced in volume, is one of the most critical parameters of this review. To obtain the best available assessment, the ARB has contracted with a team of outside experts. Their task is to review the state of the art regarding advanced battery design and manufacturing techniques, and report back to staff regarding likely cost trends for 2003 and beyond. Their draft final report will be presented at the May workshop.

The current structure of the ARB regulatory and incentive scheme for ZEVs and partial ZEVs is intended to encourage the development of advanced batteries that will allow battery EVs to achieve extended range. This approach has been taken in order to encourage the development of vehicles with sufficient range to cover the majority of trips taken by typical drivers. Some parties have argued that the ARB preference for advanced batteries should be revisited. Proponents of this view make the case that the most cost-effective application for battery EVs could be vehicles powered by lead acid batteries, and they question whether the increased range afforded by advanced batteries justifies the extra cost. Others have argued that one appropriate niche for battery EVs could be smaller, shorter-range vehicles for urban and commuter use.

Infrastructure Assessment

To achieve zero and near-zero emission levels, together with minimal upstream refueling emissions, the advanced technology vehicles being developed by manufacturers often require the use of a “fuel” other than conventional gasoline. Therefore it will be critical to ensure that the necessary refueling infrastructure is in place to support their widespread introduction.

For electric vehicles the refueling infrastructure consists of charging stations. The public infrastructure for electric vehicle charging continues to expand in California. Currently, inductive electric charging stations and conductive electric charging stations are available at about 300 and 200 public locations, respectively.

To address fuel cell vehicle and infrastructure issues, in April 1999 California Governor Gray Davis and industry leaders announced the "California Fuel Cell Partnership - Driving the Future". The partnership is a collaboration of auto manufacturers, energy providers, a fuel cell company, the State of California, the South Coast Air Quality Management District, and the United States Department of Energy, with associate partners drawn from fueling infrastructure providers and transit agencies. In addition to testing fuel cell vehicles, the Partnership will also identify fuel infrastructure issues and prepare the California market for this new technology. A key goal of the Partnership is to determine the best fuel infrastructure for the market entry of fuel cell vehicles.

The EV Market

One clear message provided at the workshop is that those who drive electric vehicles are extremely happy with them. Many speakers at the workshop testified that although they are interested in leasing an EV, they have been unable to do so because vehicles are not currently available. Several manufacturers, meanwhile, noted that from their standpoint the sale of EVs is very labor intensive and expensive relative to conventional vehicles. In general, manufacturers have argued that there are fundamental challenges to placing EVs at the required levels.

The MOA marketing efforts provide an opportunity to begin to understand the factors involved in advertising, selling and supporting electric vehicles. Lessons have been learned which will be of value in future efforts. The MOA experience does not, however, lead to definitive conclusions about the prospects for 2003.

To attempt to provide useful information as to the possible market in 2003, staff has investigated several applications that lend themselves well to being served by electric vehicles. For this exercise we assume that the vehicles would be priced to be roughly competitive to comparable conventional vehicles on a lifecycle cost basis. Rather than having a single vehicle type achieve widespread penetration, it now appears that a variety of vehicle types aimed at specialized applications will prevail. In total, staff is confident that sufficient applications exist to absorb the number of vehicles that would be required to be placed in 2003.

Staff has identified several factors that are critical to the ongoing success of the EV market. Perhaps the single greatest need is for a smooth, orderly buildup from the current base of activity towards 2003. Other important factors are providing additional vehicle platforms, public education, making all products available to retail customers, and competitive pricing.

Cost Estimation Methodology

A methodology is presented for calculation of comparative lifecycle costs for battery electric vehicles, power assist hybrid electric vehicles, and internal combustion engine vehicles. Examples are provided to illustrate the calculation method for specific sets of assumptions. The example calculations that are provided here have been chosen to illustrate a range of possible costs, and are not intended to indicate staff's assessment of likely scenarios. Staff will not present more specific estimates until the public has had a chance to review and comment on the calculation methodology and the assumptions used, and has also had an opportunity to review and comment on the work of the Battery Technical Advisory Panel.

Environmental and Energy Impacts

PENDING

Conclusion

In order to successfully place the vehicles required under the ZEV program regulations, and achieve the resulting long-term air quality and other environmental benefits, several things are necessary. The technology has arrived at the point where reliable vehicles are available, with performance characteristics sufficient to meet a range of market applications. Market applications appear to exist that can absorb the necessary number of vehicles. To achieve this potential for market penetration, the vehicles must be available at prices that are competitive to conventional vehicles on a lifecycle cost basis, which may require subsidies on a near term basis. Continuity between today's initial market and widespread vehicle introduction in 2003 is vital. Finally, there will need to be teamwork among the interested parties who follow the ZEV issue, to pursue financial incentives, development of the fleet market, and public education.

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1 INTRODUCTION

1.1 Background

Air quality in California has improved dramatically over the past 25 years, largely due to continued progress in controlling pollution from motor vehicles. Faced with ever more stringent regulations, vehicle manufacturers have made remarkable advances in vehicle technology. Several thousand zero-emission vehicles are now in everyday service on California roads, and the latest conventional internal combustion engine vehicles achieve emission levels that seemed impossible just a few short years ago.

Despite this progress, however, air quality in many areas of the state still does not meet federal or state health-based ambient air quality standards. Mobile sources still are responsible for well over half the ozone-forming emissions in California, and passenger cars and small trucks are responsible for a significant portion of the mobile source contribution. State and federal law requires the implementation of control strategies to attain ambient air quality standards as quickly as practicable.

1.2 The Zero Emission Vehicle Program

The Zero Emission Vehicle (ZEV) program was originally adopted in 1990, as part of the first ARB Low-Emission Vehicle regulations. The ZEV program is an integral part of California's mobile source control efforts, and is intended to create a market for advanced technologies that will secure increasing air quality benefits for California now and into the future. ZEVs have significant long-term benefits because they have no emission control equipment that can deteriorate or fail, and generate only minimal "upstream" refueling and fuel cycle emissions.

Under the 1990 regulations, the seven largest auto manufacturers were required to produce ZEVs beginning with model year 1998. In model years 1998 through 2000, two percent of the vehicles offered for sale in California by large volume manufacturers were to be ZEVs, and this percentage was to increase to five percent in model years 2001 and 2002, and ten percent in model years 2003 and beyond.

In 1996 the ARB modified the regulations to allow additional time for the technology to develop. The requirement for ten percent ZEVs in model years 2003 and beyond was maintained, but the sales requirement for model years 1998 through 2002 was eliminated. At that same time, the ARB entered into Memoranda of Agreement (MOAs) with the seven largest vehicle manufacturers. Under the MOAs the manufacturers must place more than 1,800 advanced-battery EVs in California in the years 1998 through 2000, and the ARB must work with state and local governments to help develop ZEV infrastructure and remove barriers to ZEV introduction.

In 1998 the ARB provided additional flexibility in the ZEV program by allowing additional types of vehicles to be used to meet program requirements. Under the 1998 amendments, manufacturers can use extremely clean advanced-technology vehicles (referred to as "partial" ZEVs) to meet the 10 percent ZEV requirement, except that large-volume manufacturers must, at a minimum, have 4 percent of their sales be vehicles classified as "full" ZEVs.

1.3 Shared Long-Term Vision

Simply put, continued reliance on today's technology will not allow California to reach its health-based air quality goals. In ARB's vision of the future, therefore, the entire vehicle fleet will produce zero tailpipe emissions, and will use fuels with minimal "fuel cycle" emissions (emissions that occur due to vehicle refueling and the related production or transportation of fuel). As an ancillary benefit to the advanced technologies employed, the future vehicle fleet also will be highly energy efficient, use diverse energy sources, and will result in reduced emissions of greenhouse gases.

Based on staff conversations and briefings with the large automobile manufacturers, it appears that most automakers share this vision. There is a general consensus that global customer demands will reward companies that can meet society's transportation needs while eliminating harmful environmental impacts. Thus, although there may be disagreements over the pace of change and the path to be followed, the ultimate goal is not in question.

1.3.1 Continued Emphasis on Zero Emissions

Battery-powered electric vehicles and other ZEVs such as hydrogen fuel cell vehicles hold distinct air quality advantages over technologies that use a conventional fuel such as gasoline in a combustion engine. High volatility liquid fuels such as gasoline are responsible for significant fuel cycle emissions. Vehicles with combustion engines inevitably exhibit deterioration that results in increased emission levels as the vehicle ages. They are also subject to becoming gross polluters if critical emission control systems fail. Although new vehicles have more durable emission control systems and on-board diagnostic systems that are effective in alerting owners to emission related problems, owners may not respond to failure signals promptly. The inspection and maintenance program will not capture vehicles that are operated without being registered, and repair cost limits may permit continued operation of some high emitting vehicles.

For all of these reasons, vehicles with no potential to produce emissions are the "gold standard" of even the cleanest, most advanced new technologies. The commercialization of ZEVs is critical to the long-term success of California's clean air program. Even with the full implementation of the LEV II program, emissions from light duty vehicles will still represent a significant portion of total emissions in the South Coast Air Basin. Achieving the new air quality standards for particulate matter, not to mention the state ozone standard, will require further reductions. Taking into account the anticipated growth in the number of light-duty vehicles and the number of miles they travel each day, it is clear that we need to eliminate emissions related to vehicle deterioration and fuel use from a significant portion of the light-duty vehicle fleet. ZEVs can accomplish this goal.

1.3.2 Near-Zero Technologies Also Play a Major Role

The ZEV requirements have been instrumental in promoting battery, fuel cell, component and vehicle research and development. These requirements have also been successful in spawning a large variety of extremely low-emission vehicle technologies. Many of these technologies have at least some of the desirable qualities inherent to ZEVs, such as extremely low emissions of smog precursors and toxic air contaminants, reduced emissions of greenhouse gases, extended durability, or high efficiency.

Such vehicles will play a major role in achieving further air quality improvement. First of all, because many of the technologies can be adopted at relatively low cost, vehicles using these technologies have the potential for widespread early market penetration without the need for subsidies or other incentives. Although the near-ZEV vehicles are not as clean as ZEVs, if produced in large numbers they provide a significant air quality benefit relative to the conventional vehicles that they replace.

Second, because many of these vehicles use components also found on zero emission vehicles (e.g. battery packs, controllers, and electric drive), volume production of near-zero vehicles will help reduce the cost of components used on zero emission vehicles and hasten their commercialization.

1.3.3 Linkage to Broader Issues

The mission of the Air Resources Board is to protect public health through the reduction of air pollution. The Board's primary focus is on the reduction of smog-forming pollutants and toxic air contaminants. To date, most discussion of ZEV air quality impacts has focused on their smog benefits.

In addition to their dramatic reduction in smog-forming pollutants, ZEVs also provide reductions in the emissions of toxic air contaminants. The benefits of reductions in toxic air contaminants are felt statewide. Recognizing that mobile source pollution from highway traffic may disproportionately affect nearby inner city and low-income neighborhoods, reductions in toxic emissions from motor vehicles can also help address community level public health concerns.

Above and beyond these traditional air pollution benefits, ZEVs can also make significant positive contributions in other environmental areas. For example, the use of alternative fuels can reduce the multimedia impact of fuel spillage on water quality, and can increase the diversity of California's energy supply. The smooth, quiet operation of electric drive vehicles can improve the quality of life in crowded urban areas. Electricity and hydrogen, which can be used to power ZEVs, can be produced from renewable resources such as solar, wind or hydropower, or biomass feedstocks. Thus these technologies can help pave the way towards a sustainable energy future.

Perhaps the most important ancillary benefit, though, is that high-efficiency ZEVs and hybrid electric near-ZEVs can lead to significant reductions in emissions of CO_2 and other greenhouse gases. The Air Resources Board does not currently regulate emissions of greenhouse gases. The Board is, however, working with the California Energy Commission to better understand the contribution of mobile sources to total greenhouse gas emissions, and quantify the climate change impact of various fuels and vehicle technologies. Even in the absence of specific regulatory requirements it is clear that, other things being equal, technologies that achieve lower greenhouse gas emissions are the preferred alternative. Meanwhile, auto manufacturers worldwide are working to reduce greenhouse gas emissions from their vehicles in keeping with the Kyoto Protocol and other requirements in place or pending in other markets.

ZEVs also can benefit California's economy as well as our public health. Because of their high-technology leadership, California companies have the technical and scientific capability to play a significant role in the design, development and production of advanced technology zero emission components and vehicles. ARB is currently developing estimates of some of the economic benefits of the ZEV program.

ZEVs thus have the capability to provide comprehensive environmental, energy and societal benefits. While the Board's consideration of the ZEV regulation is firmly rooted in its air quality mandate and authority, the Board is aware of the multi-faceted effects of its policy choices. Over the long term the Board, in cooperation with its sister agencies, will devote increasing attention to an integrated consideration of such broader issues.

1.4 Progress Since the 1998 Biennial Review

Perhaps the best way to characterize progress over the two years since the last Biennial Review is to say that EVs have rapidly moved into widespread real world applications.

In July of 1998, when the last Biennial Review staff report was released, manufacturers had just introduced their vehicles. On March 29, 2000, numerous enthusiastic EV drivers arrived en masse in their leased vehicles to testify at the ZEV Review workshop in Sacramento. Others arrived in rental electric vehicles they had picked up at the Sacramento airport. On that same day, dozens of EVs were at work elsewhere in the Sacramento area for a variety of state and local agencies. Down Interstate 80 in West Sacramento, plans were underway for a groundbreaking ceremony for the headquarters of the California Fuel Cell Partnership. In Los Angeles, electric minivans were in use shuttling passengers to and from Los Angeles International Airport. In Yosemite Valley, two electric vehicles provided zero emission mobility for park staff and visitors. In the Bay Area, San Diego, Ventura, the Gold Country, the San Joaquin Valley, Los Angeles, and elsewhere around the state, electric vehicles were in daily use. Some specific highlights of recent progress include:

- More than 2,300 electric vehicles in a variety of configurations have been delivered for lease or sale in California.
- All of the required MOA vehicles produced to date have been successfully leased. At present there are more interested customers than there are vehicles available.
- General Motors has released the “Generation II” NiMH version of the EV1, featuring a range of 142 miles, and a NiMH version of the S-10 pickup.
- DaimlerChrysler released a NiMH version of the EPIC minivan.
- EPIC minivans using fast charge are in daily use by Xpress Shuttle serving passengers at Los Angeles International Airport.
- Ford has released a NiMH version of the Ranger pickup.
- Ford has created a Th!nk subsidiary to market advanced technology vehicles, and has announced plans to market City and neighborhood sized EVs.
- Ford introduced an innovative and successful program to market the EV Ranger to schools and parks at a reduced rate of $199 per month.
- The United States Postal Service has ordered 500 electric vehicles, based on the Ford Ranger platform, for mail delivery in California.
- Honda has begun to re-market vehicles after the expiration of the original three year lease, resulting in additional zero emission miles of service.
- Toyota has introduced vehicles with a second generation, smaller, inductive charging paddle.
- Nissan has introduced the first electric vehicle powered by lithium-ion batteries.
- Manufacturers have continued to refine and improve power control electronics, electric drivetrains, and other components. For example, General Motors is developing a Generation III electric drivetrain.
- Southern California Edison operates a fleet of 320 EVs, which has logged more than 3.5 million miles of service.
- Electric vehicles are now authorized to travel in High Occupancy Vehicle lanes regardless of the number of occupants.
- Under recent legislation, the registration fee paid by electric vehicles is now no greater than that of a comparable conventional vehicle.
- More than 120 public fleets around the state have used EVs under the ARB’s Electric Vehicle Loan Program.

- EVs are available for rent at the Los Angeles and Sacramento airports, and will soon be available at the Ontario, Burbank, and Orange County airports as well as at downtown locations in Sacramento and Beverly Hills.
- Significant additional public infrastructure has been installed around the state.
- The California Fuel Cell Partnership has been formed, with the goal of demonstrating fuel cell vehicle technology and alternative fuel infrastructure over the next four years.
- Nissan has introduced a Sentra vehicle that meets partial ZEV credit requirements.

1.5 The 2000 Biennial Review Process

When the ZEV requirement was adopted in 1990, low- and zero-emission vehicle technology was in a very early stage of development. The Board acknowledged that many issues would need to be addressed prior to the implementation date. Thus the Board directed staff to provide an update on the ZEV program on a biennial basis, in order to provide a context for the necessary policy discussion and deliberation. The next biennial review of the ZEV program is scheduled for September 2000.

The ARB is committed to working closely with all interested parties to ensure that they have an opportunity to provide comments and suggestions throughout the review process. The key milestones of the review process are as follows:

March 29, 2000	Public Workshop Background Information for the September Review Sacramento
March 30, 2000	Public Workshop Multi-Manufacturer Ownership Arrangements Sacramento
May 31-June 1, 2000	Public Workshop Background Information for the September Review El Monte
August 2000	Staff Report released to the public
September 7, 2000	Board Meeting

1.6 The Purpose of This Document

In preparing for the Board's upcoming Biennial Review, the goal of the staff is to provide a thorough, accurate portrayal of the current status of ZEV technology and the prospects for improvement in the near- and long-term. Extensive staff work is underway in a variety of areas. Staff efforts to date have included meetings with vehicle manufacturers, environmental groups, and other interested parties, on-site visits to the large vehicle manufacturers in Japan and in Michigan, discussions with EV drivers, and research on current and pending technologies and their environmental impacts. ARB also has contracted with outside technical experts to review the state of battery technology and production costs, and assess the full fuel cycle emissions and energy efficiency of various vehicle types and fuel sources. This document outlines the information developed to date.

This document is descriptive rather than proscriptive—it does not draw conclusions or make recommendations. Rather, the purpose of this preliminary draft staff report is to put forth technical information for public review and comment, develop a framework and context for consideration of the relevant issues, and provide an opportunity for interested parties to point out any errors, omissions, or other problems in the factual basis that will be made available to the Board.

Comments are welcome on all aspects of this material. Following the May 31-June 1 public workshop and the review of all comments received, staff will make changes as appropriate and release the final Staff Report and Technical Support Document in August. By following this process we hope to provide a firm, agreed-upon technical basis for the Board's policy review and discussion at the September Board meeting.

1.7 Public Comments to Date

At the March 29 public workshop, three public comment sessions were conducted. These sessions addressed the preliminary staff assessment, the EV driver experience, and advances in ZEV technology. Seventy-three individuals testified at the workshop, and staff has also received nearly forty separate written submittals.

In seeking public comment, staff hoped to identify areas where the staff report could be strengthened or improved, and bring to light issues that the public believes should be highlighted for the Board's consideration. The extensive public comment provided has been valuable during preparation of this updated version of the document.

Major themes outlined in the public comment are discussed below. This listing is not intended to cover every point raised, but rather to note areas of significant emphasis.

<u>ARB Leadership Role</u>.

Numerous commenters stated that the ARB's leadership in adopting the Zero Emission Vehicle program in 1990 is the root cause of much of the recent progress in vehicle emission control. They called upon ARB to maintain this leadership role by sustaining the regulation.

Environmental and Energy Impact.

Several commenters urged that staff fully consider a wide range of environmental benefits from ZEVs. From an air quality standpoint, they recommended additional focus on "real world" emissions, which they contend can be higher than the estimates provided by ARB emission models. They also recommended full consideration of upstream emissions (emissions from refining, transport and refueling) for gasoline vehicles, and a similar emphasis on toxic emissions. They noted that toxic emissions from motor vehicles, fueling infrastructure and refining can have a disproportionate impact on nearby populations, and stated that ARB should recognize the resulting environmental justice implications. Finally, they asked staff to fully consider the CO2 emissions from internal combustion vehicles and the resulting contribution to global climate change.

Commenters also asked that staff consider multimedia environmental impacts, such as the damage to water quality caused by leaking underground fuel tanks. Commenters also urged ARB to pay attention to the energy diversity implications of different fuel choices.

In response to these suggestions, the former Emission Benefit section has been renamed, and is now entitled Environmental and Energy Impacts. This is intended to highlight the broad nature of the issues being considered.

Unmet Current Demand For Vehicles.

Many speakers at the workshop testified that they are interested in leasing an EV, but have been unable to do so because vehicles are not currently available. For example, drivers who lost the use of an EV1 due to the General Motors recall, and who wish to replace the EV1 with another electric vehicle, have in most cases been unable to do so. Similar information has also been received via written submittals from other individuals subsequent to the workshop. Testimony was also provided by a fleet manager who has been unable to procure the desired number of vehicles for his fleet.

The EV Lease Process.

Staff received testimony and written submittals from individuals indicating that in their view they had to overcome unusual barriers in order to lease an EV. Examples include sales staff who are unfamiliar with the vehicles, long delays in getting information, ambiguous or contradictory information regarding "waiting lists" to obtain vehicles, and long delays in getting vehicles once orders have been placed. A more general point was also made that it is difficult for the public to get information regarding electric vehicle alternatives and their characteristics.

Several manufacturers, meanwhile, noted that from their standpoint the sale of EVs is very labor intensive and expensive relative to conventional vehicles. For example, staff need extensive training, additional time and effort is needed to educate customers regarding new technology, the ratio of sales to initial inquiries is relatively low, and time and effort are needed to deal with infrastructure installation issues.

Vehicle Performance.

One clear message provided at the workshop is that those who drive the vehicles are extremely happy with them. Numerous drivers took personal time off from work and journeyed to Sacramento just to emphasize their satisfaction with their vehicles and their desire that the availability of ZEVs be expanded. A fleet manager also described the extensive real-world service that his fleet of EVs has provided in a variety of applications. Staff notes that the number of commenters who wished to address this point was so large that it was necessary to severely limit the amount of time available for each speaker in that section of the workshop.

Real vs. Perceived Range Needs.

Many drivers remarked that when they first considered an EV, they had an estimate in mind regarding the portion of their driving that could be accommodated within the available range. After living with the vehicle, however, they learned that their actual driving patterns were less demanding than they had imagined, and therefore they were able to use the EV far more than they had anticipated. Drivers noted that this “mismatch” between perceived and actual range needs is an artificial barrier to more widespread demand for EVs.

The Cost of Additional Range.

On a related point, several commenters argued that existing lead acid technology is adequate to meet real world driving needs, and provides the most cost effective way to bring about significant “zero emission miles traveled”. They stated that although advanced batteries can provide additional range, the resulting cost penalty is so great that it reduces the overall appeal of the vehicle.

Lifecycle Cost.

Several commenters stated that any cost comparison between EVs and conventional vehicles should look at the total cost of ownership over the life of the vehicle, taking into account ongoing savings in fuel and maintenance. Staff notes that the cost methodology employed in this document follows this approach.

Automaker Experiences To Date.

Several commenters discussed the automakers' commitment to clean air, the vehicles that have been produced to date and their product strategy, and manufacturers' observations regarding their experience to date. These commenters argued that there are fundamental challenges to placing EVs at the required levels, due to high cost, limited range, and the difficulties inherent in achieving widespread market penetration with a new technology.

Recommended Changes to the Regulation.

Several commenters recommended that the ZEV regulation be strengthened. One suggestion was that partial ZEV credit should not be granted to any gasoline fueled vehicle; another was that the sales regulation be expanded to include higher weight classes (e.g. minivans, light trucks, and sport utility vehicles)

Two manufacturers recommended that the minimum sales volume threshold for the "intermediate" and "large" manufacturer classifications be increased.

2 MANUFACTURER STATUS

2.1 Introduction

The ZEV requirement applies to large and intermediate volume manufacturers (defined below). Beginning in model year (MY) 2003, at least 10 percent of the passenger cars and light duty trucks below 3,750 pounds gross vehicle weight produced and delivered for sale in California by large and intermediate volume manufacturers must be ZEVs. An intermediate volume manufacturer may meet this ZEV requirement entirely with partial ZEV allowance vehicles (defined in Section 4.3.1) or credits generated by such vehicles. A large volume manufacturer must meet at least 40 percent of its ZEV requirement with pure ZEVs, full ZEV allowance vehicles, or credits generated by such vehicles. Large volume manufacturers may, at their option, meet the remaining 60 percent of their ZEV requirement with partial allowance vehicles or credits generated by such vehicles. A small volume manufacturer is not required to meet the percentage ZEV requirements, but may earn and market credits for the ZEVs or ZEV allowance vehicles it produces and delivers for sale in California.

2.2 Manufacturer Volume Classifications

Because MY 2003 is quickly approaching and planning for MY 2003 production is well underway, ARB staff has attempted to establish each manufacturer's volume classification and, thus, each manufacturer's ZEV requirement.

For purposes of classification for 2003, small volume manufacturers are defined as those with California sales below 4,500 per year, using the average number of vehicles sold over the preceding three years. Small volume manufacturers are not subject to the ZEV requirement. Based on current production and sales data, ARB staff expects the small volume manufacturers in MY 2003 to be the following:

- Dae Woo
- Ferrari
- GFI
- Lamborghini
- Lotus
- Porsche
- Rolls Royce
- Saab
- Suzuki

Intermediate volume manufacturers are defined for 2003 as those with California sales between 4,501 and 35,000 light and medium duty vehicles per year, again averaged over the preceding three years. Based on the same data, ARB staff expects the intermediate volume manufacturers in MY 2003 to be the following:

- BMW
- Subaru (Fuji)
- Hyundai
- Isuzu
- Jaguar
- Kia
- Mazda
- Mitsubishi
- Rover
- Volkswagen
- Volvo

Large volume manufacturers are defined as those that are not small volume manufacturers or intermediate volume manufacturers. Based on the same data, ARB staff expects the large manufacturers in MY 2003 to be the following:

- DaimlerChrysler
- Ford
- GM
- Honda
- Nissan
- Toyota

During public comment at the March workshop, one manufacturer recommended that the minimum annual sales threshold for a large manufacturer be increased above the current level of 35,000. This manufacturer noted that automakers just above this cutoff are far more limited in resources than the existing large manufacturers, who typically have annual California sales of at least 100,000 and often substantially more. Another manufacturer made a similar recommendation, with similar reasoning, regarding the minimum annual sales threshold for an intermediate volume manufacturer, currently set at 4,500. Staff is not considering modifications to the regulation at this time, but has noted the recommendation.

2.3 Potential Classification Changes

Although previously categorized as a large-volume manufacturer, Mazda has consistently been selling fewer than 35,000 vehicles in California in recent years. Mazda will be considered an intermediate volume manufacturer beginning in MY 2003 if its production volume remains at the current level.

BMW and Volkswagen have each been selling approximately 35,000 vehicles per year in California in recent years. If their 2000 through 2002 MY average sales exceed 35,000, they will need to meet ZEV requirements as large volume manufacturers beginning in MY 2006.

Subaru, which is currently considered an intermediate volume manufacturer, has been selling near the lower limit of the intermediate volume manufacturer classification in California in recent years. Therefore, depending on its actual sales in model years 2000 through 2002, Subaru may be classified as either an intermediate or a small volume manufacturer in MY 2003.

In 1998 Isuzu produced only light duty trucks between 3,751 and 5,750 pounds gross vehicle weight (LDT2s), which are not subject to the ZEV requirement. Rover produced only medium duty vehicles, also not subject to the ZEV requirement. Therefore, although Isuzu and Rover are intermediate volume manufacturers, they will not need to produce any ZEVs in MY 2003 if they continue to produce only LDT2 and medium duty vehicles.

2.4 Multi-Manufacturer Ownership Arrangements

In recent years there have been many new multi-manufacturer arrangements, which have made it difficult to delineate individual companies. For example:

- Ford fully owns Volvo and Jaguar, and partially owns Mazda
- General Motors fully owns Saab, and partially owns Suzuki and Subaru
- BMW fully owns Rover
- Nissan is fully owned by Renault
- Volkswagen fully owns Rolls Royce
- Kia is partially owned by Hyundai, Ford, and Mazda

Thus the question arises—against what base should the “10 percent of sales” ZEV obligation be assessed? Currently, manufacturer sales numbers are not aggregated if the manufacturers are “operationally independent”. Because the meaning of this term is not always readily apparent given the variety of ownership situations, ARB staff held a workshop on March 30, 2000 to clarify the ZEV-related emission compliance liabilities of companies in multi-manufacturer arrangements. Manufacturers are currently reviewing the implications of using the CAP2000 aggregation provisions for this purpose and are also developing, for further discussion and consideration, criteria to better specify the “operational independence” test. The resulting policy will be implemented either by regulatory amendments or through issuance of a Manufacturer’s Advisory Correspondence. Appropriate lead time will be provided before any changes become effective.

2.5 ZEV Production to Date by Large Manufacturers

The ZEVs that have been placed in California by large manufacturers are described in the following table.

Manufacturer	Model	Battery Type	Lease Cost ($)	City Range	Highway Range	Number Placed
Daimler Chrysler	EPIC	PbA	NA	70	65	17
	EPIC	NiMH	450	92	97	93
Ford	Ranger	PbA	varied	84	69	52
	Ranger	NiMH	450	94	86	327
GM	EV1	PbA (Delco)	349	75	78	606
	EV1	PbA (Panasonic)	424	111	113	0
	EV1	NiMH	499	143	152	162
	S-10	PbA	439	46	43	110
	S-10	NiMH	440	92	99	117
Honda	EV Plus	NiMH	455	125	105	276
Nissan	Altra	LiIon	599	120	107	81
Toyota	RAV4	NiMH	457	142	116	486

Please note that all range figures used in this document are based on the urban dynamometer driving schedule (UDDS) and the highway fuel economy driving schedule (HFEDS) test cycles. Lease prices shown include governmental incentives.

Overall, manufacturers have adopted similar strategies to make these vehicles attractive to customers. The vehicles typically are available via a three-year lease without a down payment. This reduces the risk to the customer that their vehicle will be obsolete in a few years due to technical advances. Similarly, the warranty provided on the vehicles is comprehensive, and covers all components. This eliminates any durability issues or concerns on the part of the customer. Several manufacturers also include a charger in the lease. Finally, the lease typically includes roadside assistance services.

Because production levels for these vehicles are not yet sufficient to justify assembly line tooling and manufacturing techniques, in many (but not all) cases the vehicles have been produced in a “batch” process. Under this method, a small quantity of vehicles is built at one time. A new batch is produced when necessary.

Some details regarding the specific activities of each manufacturer are provided in the EV Market section below.

2.6 ZEV Volume Estimates for 2003

California sales of passenger cars plus light duty trucks by the large automobile manufacturers total approximately one million vehicles per year. As a rule of thumb, therefore, each one percent of vehicle sales equals about ten thousand vehicles per year.

The calculation of the actual number of vehicles needed to meet the ZEV requirement in any given year is considerably more complex, however, due to several factors:

- Manufacturers can earn “multipliers” for vehicles with extended range, with additional allowances for vehicles delivered prior to 2003. Taken together these two factors can result in up to 10 allowances per vehicle for vehicles delivered in MY 1999 and 2000. Specifically, each ZEV and full ZEV allowance vehicle that is produced and delivered for sale in California in the 1999 to 2007 model years, and that has an extended electric range, qualifies for a ZEV multiplier as shown below. These multipliers are based on range alone and are not dependent on the type of battery or the battery specific energy.

All-electric range	MY 1999-2000	MY 2001 -2002	MY 2003-2005	MY 2006-2007
100-175	6-10	4-6	2-4	1-2

- In addition to the multipliers discussed above, ZEV credits “banked” in a prior year have greater value when “cashed” in a subsequent year, based on the relative values for the NMOG fleet average for the years in question. Under this provision, for example, ZEV credits earned in 1999 are multiplied by 1.82 if used in 2003, and credits earned in 2000, 2001 and 2002 are multiplied by 1.18, 1.13, and 1.1 respectively. Taking into account all available multipliers, a single 175 mile range vehicle placed in 1999 would earn 18.2 allowances.
- Manufacturers are given one additional model year to make up any shortfall in ZEV production. Thus, a manufacturer could choose to satisfy both its 2003 and 2004 obligation with vehicles delivered in 2004.
- In order to meet their obligation, large manufacturers must offer for sale a minimum of 4 percent pure ZEVs. They may, however, choose to meet the entire 10 percent requirement using pure ZEVs.

To provide a context for the Board’s evaluation of the ZEV program, staff have developed a "base case” estimate of the number of ZEVs that the large manufacturers must produce in 2003 in order to satisfy the 4 percent ZEV requirement. Due to trade secret considerations this estimate does not rely on any confidential information provided in the manufacturer product plans. Instead, it is calculated using publicly available information, with the following assumptions:

- The vehicles offered for sale in 2003 are identical in performance to the vehicles currently or most recently offered by the manufacturers. (The specific vehicles, their test cycle range, and the resulting number of allowances earned per vehicle are shown below.)

- Manufacturers do not take advantage of the multipliers available for early introduction; the entire 2003 obligation is met with vehicles produced in 2003.
- Each manufacturer's production volume in 2003 is equal to its production volume in 1998.
- Manufacturers meet 60 percent of their ZEV obligation using partial ZEV allowances, and 40 percent of their obligation (4 percent of sales) using pure ZEVs. (An estimate assuming that manufacturers meet their entire 10 percent obligation with pure ZEVs, using no partial ZEV allowances, is shown for comparison purposes.)

With these assumptions, 2003 pure ZEV production would be as follows:

Manufacturer	1998 Production	ZEV model	Urban Range	Multiplier per vehicle	2003 ZEV Obligation	
	(PC+LDT1)		(miles)		4%	10%
GM (see note 1)	84,106	1999 NiMH EV1	143	3.144	1,070	2,675
	84,106	1999 PbA EV1	111	2.293	1,467	3,667
	42,053	1999 NiMH S10	92	1.000	1,682	4,205
TOYOTA	201,473	1998 RAV4 EV	143	3.141	2,565	6,414
FORD	186,977	1999 NiMH Ranger	71	1.000	7,479	18,698
HONDA	172,768	EV Plus	125	2.672	2,586	6,466
NISSAN	88,455	2000 Altra	129	2.773	1,276	3,189
DAIMLER CHRYSLER	105,691	1999 NiMH EPIC	92	1.000	4,228	10,569
TOTAL	965,630				22,353	55,884

Note 1: This estimate assumes that GM sales are 40% NiMH EV1, 40% Panasonic PbA EV1, and 20% NiMH S10.

This estimate, at roughly 22,000 vehicles, corresponds to about 2.3 percent of the passenger car and light duty truck production of the affected manufacturers. It must be noted, however, that actual 2003 ZEV production may vary significantly from this number due to the various factors discussed above.

Manufacturers are required, under the Memoranda of Agreement with the ARB, to submit confidential product plans outlining the product mix that they will use to meet the 2003 requirement (see Section 3.2.3 below). All manufacturers submitted these plans on a timely basis. All manufacturers demonstrated that they have the technical capability to produce the quantity of vehicles needed to meet their 2003 obligation. The manufacturers uniformly argued, however, that the cost of these vehicles remains high, and foreseeable battery technology will result in limitations on vehicle range. Thus in their view it will be very difficult to develop a self-sustaining mass market for battery electric vehicles at this time.

Staff notes that technical advances are steadily reducing the cost premium associated with ZEVs and that increased production volume will bring about further reductions.

3 COMPLIANCE WITH THE MEMORANDA OF AGREEMENT

3.1 Introduction

In 1996, the Executive Officer of the Air Resources Board and all seven large auto manufacturers signed Memoranda of Agreement (MOAs). The large auto manufacturers who signed the MOAs are General Motors, Ford, Chrysler (now DaimlerChrysler), Honda, Nissan, Toyota, and Mazda. The MOAs are intended to ensure the successful introduction of zero emission vehicles into the marketplace. They include binding commitments from each of the seven auto manufacturers as well as from ARB.

Under the MOAs, the auto manufacturers committed to:

- Offset the emission benefits lost due to the elimination of the ZEV requirement for 1998 through 2002;
- Have the capacity to produce a certain number of ZEVs that could be sold in California if warranted by customer demand. The exact number was separately and confidentially determined by each manufacturer.
- Submit annual progress reports, and biennial product plans outlining how they will comply with the 2003 requirement;
- Participate in a technology development partnership, including continued investment in ZEV and battery research and development, and placement of advanced battery-powered ZEVs in marketplace demonstration programs;
- Collaborate with the ARB and the State Fire Marshal on ZEV safety training; and
- Provide the ARB with an on-site review of manufacturer activities and hardware related to the ZEV program.

The ARB, meanwhile, committed in the MOAs to working with state and local governments and others to help develop ZEV infrastructure and remove barriers to ZEV introduction. Specifically, the ARB must:

- Facilitate the purchase of ZEVs in state fleets;
- Address insurance and financing issues;
- Work with other state agencies to ensure the availability of battery recycling;
- Work with local governments on planning and permitting of charging stations;
- Work with utilities and electrical contractor trade groups to ensure adequate training for installation and maintenance of EV charging systems;
- Support the efforts of the National Electric Vehicle Infrastructure Working Council;
- Work with the State Fire Marshal and other emergency response officials to create a comprehensive ZEV emergency response training program;
- Observe the activities of the U.S. Advanced Battery Consortium; and
- Support the development and implementation of reasonable incentive programs that enhance the near-term marketability of ZEVs.

3.2 Manufacturer Commitments

All of the large auto manufacturers submitted the annual reports and the product plans as required. These reports outline the progress made towards meeting the requirements of the MOAs. The following information is based on the manufacturers' submittals as well as private meetings and phone conversations with manufacturers.

Staff concludes that the manufacturers and the ARB have met the commitments made in the MOAs. The remainder of this chapter provides detail on the individual tasks.

3.2.1 Cleaner Cars Nationwide (National Low-Emission Vehicle Program)

The MOAs require the auto manufacturers to introduce low-emission vehicles nationwide in 2001, three years earlier than could be required under federal law. The National Low Emission Vehicle (NLEV) program was included in the MOAs to offset the emission increases associated with the 1996 revisions to the ZEV program, and thereby maintain the integrity of ARB’s State Implementation Plan. Because non-California vehicles frequently travel through California or relocate to California from other states, cleaning up non-California vehicles results in emission reductions within California’s borders. A 1996 ARB staff analysis indicates that by 2010 the NLEV program will result in emission reductions that are equivalent to those that would have occurred had the original ZEV program production requirement for 1998 through 2002 remained in place.

In March 1998, the U.S. Environmental Protection Agency (EPA) announced that 23 automobile manufacturers--including the seven manufacturers that signed the MOA--and nine northeastern states have agreed to the new voluntary NLEV program. Starting in 1999, light-duty vehicles and light-duty trucks sold in the northeast are meeting more stringent emission requirements. The program will be expanded nationally in 2001. This agreement between the EPA and the auto manufacturers will fulfill the MOA obligation.

3.2.2 Market-Based ZEV Launch

The MOAs express the auto manufacturers’ commitment to have the capacity to produce a certain number of ZEVs “that could be sold in California if warranted by customer demand” (Section I.B.). The specific number was separately and confidentially determined by each manufacturer. These vehicles are in addition to the demonstration vehicles discussed under Section 3.2.4.2 below. The purpose of this element of the MOA was to ensure that manufacturers have the production capacity to meet market demand for ZEVs during the ramp-up period prior to 2003. Attached to each MOA as Exhibit A was the manufacturer’s confidential November 1995 submittal identifying the manufacturer’s annual capacity to produce ZEVs for the 1996 through 2002 model years, in accordance with their estimate of market readiness.

The timing of vehicle introduction by the various manufacturers has varied, based upon the type of vehicle, the battery employed, specific technical challenges that needed to be overcome, and near-term targeted markets. As of January 2000, Ford, General Motors, Honda and Toyota have placed vehicles above and beyond those required under the MOA demonstration program.

The RAV 4, Altra and EPIC vehicles are currently only marketed to fleets, and production quantities are limited. Honda has announced that it will not produce additional vehicles, and will focus its efforts on evaluating customer satisfaction and providing customer support for vehicles currently in service. The net result of these manufacturer actions is that fleet customers face limited product availability, and the only vehicle currently available to retail customers is the EV1. Thus there is no four passenger, family vehicle available to the public.

The manufacturers have concluded that those most likely to lease the current ZEV products are fleet managers, or a small subgroup of highly educated, high-income "early adopters". Thus most marketing efforts have been targeted at these specialized groups, rather than at the general public.

Some parties have argued that the limited vehicle advertising and the limited availability of vehicles constitutes evidence that manufacturers are not complying with their MOA commitment to have the capacity to produce vehicles to meet customer demand.

As defined in the MOA, *"Capacity to produce" means that the manufacturer has available adequate vehicle production facilities either in-house or contractually with others, including the in-house ability or outside contracts sufficient to supply major vehicle parts and component needs. "Capacity to produce" does not obligate the manufacturer to produce, deliver or sell a specified number of ZEVs.* (Definitions, Section X.D.). A lack of available product therefore does not in and of itself signify noncompliance with the MOA.

An evaluation of compliance with the market-based ZEV launch requirement of the MOAs also requires an interpretation of the phrase "if warranted by customer demand". In the view of staff, a reasonable interpretation of customer demand implies demand that exists when the vehicle is priced at or near the manufacturer's cost. The current lease rates for the vehicles do not recover the relatively high cost of producing an EV today. Although it is common for manufacturers to sell some vehicles at a loss for larger corporate strategy purposes, the current differential between the lease prices for battery electric vehicles and the manufacturers' cost is substantial. Manufacturers have used various methods to determine the lease prices used for today's vehicles, but in no case have the vehicles been priced at a level that is close to the manufacturers' cost. Although we do not know what demand would exist if the vehicles were priced to recover at least the majority of their cost, presumably it would be less than that seen over the past several years.

In sum, staff concludes that manufacturers are in compliance with their commitment to have the capacity to produce vehicles that could be sold in California if warranted by customer demand.

3.2.3 Zero Emission Vehicle Product Plans

Under the MOAs, the manufacturers are required to submit ZEV product plans prior to November 1 of the year preceding the scheduled review (in this instance, prior to November 1, 1999). Each manufacturer must submit corporate product plans that demonstrate compliance with the ZEV requirement for 2003. All of the manufacturers submitted the required plans on a timely basis. The product plans identify the manufacturers' strategies for 2003, including key decision points and other milestones.

ARB staff have carefully reviewed the product plan submittals. Staff also made site visits to Japan and Michigan to tour the manufacturers' research and development facilities, and receive briefings on their research efforts. Based upon the review and site visits, staff is confident that the product plans accurately represent the status of work at the manufacturers.

The information in these confidential product plans provides part of the basis for the staff assessment of the current status of ZEV technology, discussed elsewhere in this document.

3.2.4 Technology Development Partnership

Under the Technology Development Partnership component of the MOA, the auto manufacturers agreed to make good faith efforts to promote and develop a market for ZEVs and to ensure ongoing ZEV-related research and development. To accomplish this effort, each manufacturer committed to continue battery research and development throughout the term of the MOA, and to place new ZEVs with advanced technology batteries into service in California through the advanced technology battery demonstration project.

3.2.4.1 Research and Development

All of the large manufacturers have extensive internal research and development efforts underway. The briefings and staff site visits in Michigan and Japan conclusively demonstrated that all manufacturers are actively pursuing a full range of zero and near-zero emission vehicle technologies. The extensive staffing levels and other resource commitments dedicated to advanced technology give evidence of the manufacturers' conviction that customer demands will force ongoing environmental improvement. Staff was impressed with the intense work underway in a variety of program areas, and the commitment by all manufacturers to play a leadership role in the commercialization of zero and near-zero emission vehicles.

In addition to in-house efforts, under the terms of the MOA General Motors committed to contribute $8.9 million during Phase II of the United States Advanced Battery Consortium (USABC), while DaimlerChrysler and Ford have committed $3.34 and $6.67 million respectively. All three manufacturers are on target with their contributions and will completely contribute the full amounts by 2002.

3.2.4.2 Advanced Technology Battery Demonstration Project

The auto manufacturers each also agreed to produce their pro-rata share of up to 3,750 advanced battery vehicles between 1998 and 2000, and place them in demonstration programs designed to validate the new technology. Table 3-1 on the next page shows each manufacturer's share of the total ZEVs to be placed in demonstration programs.

To receive MOA ZEV credit towards the commitments enumerated in Table 3-1, a ZEV must use advanced batteries. For the purposes of the MOAs, "advanced battery" means a battery with a specific energy of at least 40 watt-hours per kilogram (Wh/kg) for the 1998 calendar year and at least 50 Wh/kg for 1999 and subsequent calendar years. (Specific energy is the amount of energy per unit of weight and is related directly to range).

Table 3-1
Auto Manufacturer MOA Advanced Battery Demonstration Commitments

Calendar Year	Number of Vehicles (Based on Average Market Share)							Total by Year
	Chrysler	Ford	General Motors	Honda	Mazda	Nissan	Toyota	
1998	51	181	182	101	28	70	135	748
1999	103	363	365	202	55	141	271	1,500
2000	103	363	366	203	55	141	271	1,502
Total								3,750

The amount of credit given in the MOA for an advanced battery-powered ZEV is based on the specific energy of the batteries. Manufacturers may reduce the total number of ZEVs required if the batteries used in the vehicles have a specific energy greater than 50 Wh/kg. Table 3-2 on the next page indicates the number of credits that are granted for ZEVs that use advanced batteries.

Table 3-2
MOA ZEV Credits Allowed for an Advanced Battery-Powered ZEV

Specific Energy	Number of ZEV credits allowed
40 Wh/kg (1998 only) 50 Wh/kg (1999 and 2000)	One
60 Wh/kg	Two
90 Wh/kg	Three

The advanced battery-powered vehicles that are being produced today have specific energy ratings of between 55 and 85 Wh/kg depending on the battery technology used. It is expected that advanced battery-powered EVs to be marketed in 2003 will fall approximately within this range as well.

Linear interpolation is used to determine the number of MOA credits earned by ZEVs with specific energy over 50 Wh/kg. Therefore, ZEVs placed as part of the Technology Development Partnership are generating from 1.5 to 2.8 MOA ZEV credits per vehicle. As a result, the actual number of vehicles to be produced to meet the auto manufacturers' advanced battery vehicle MOA commitments will be approximately 1,800 rather than 3,750.

In early 1999, both Honda and Toyota completed placement of advanced battery-powered electric vehicles for the Technology Development Partnership. General Motors, Ford, DaimlerChrysler and Mazda are on track to complete their commitments by the end of 2000. Nissan requested and received approval to delay placement of a small portion of their vehicles for one year (until 2001) due to a battery supplier issue.

As of January 2000 there were already more than 1,300 advanced battery electric vehicles placed in California as a result of this project. At the conclusion of the project, there will be more than 1,800 electric vehicles operating on advanced technology batteries on the roads of California.

3.2.5 Annual Reports

The MOAs require manufacturers to file an annual report within 90 days after the close of each calendar year. The annual reports must provide information regarding ZEVs placed in California and elsewhere in the United States during the previous calendar year. The annual report must also contain information regarding the placement of ZEVs under the Technology Development Partnership. All manufacturers have submitted their annual reports as required.

3.2.6 Collaboration with ARB and State Fire Marshal

The MOAs require manufacturers to collaborate with the ARB and the State Fire Marshal to develop the curriculum and materials necessary for a comprehensive ZEV safety-training program. This training program was completed in 1998.

3.2.7 On-Site Review

The MOAs require the manufacturer to provide ARB staff with an on-site review of activities and hardware related to the manufacturer's ZEV program. ARB staff visited Honda, Nissan and Toyota facilities in Japan in December 1999, and visited General Motors, Ford and DaimlerChrysler facilities in Michigan in February 2000. During these visits ARB staff received extensive briefings on the manufacturers' activities, and had the opportunity to view and/or test-drive a variety of vehicles. As a result of these visits and the information that has been provided, ARB staff have a thorough understanding of the status of work at each manufacturer.

3.3 Air Resources Board Commitments

As its part of the MOA, ARB committed to a number of tasks aimed at making California ready for the ZEV market. The following sections summarize the activities that the ARB has undertaken or supported to meet the commitments made in the MOA.

3.3.1 Purchase/Lease of EVs by State and Local Governments

The MOAs specify that ARB must facilitate the purchase of ZEVs for appropriate applications in state fleets. ARB must work with the California Department of General Services and the California Energy Commission to establish vehicle specifications for the State Bid List, and work with the Department of General Services Office of Fleet Administration to ensure the sale or lease of ZEVs to selected state agencies.

The Department of General Services has executed Master Service Agreements with the General Motors Acceptance Corporation (for the EV1 and the Chevrolet S-10), American Honda Motor Co., Inc. (for the EV PLUS), Toyota Motor Company (for the RAV4), and Ford Motor Credit (for the Ford Ranger). These Master Service Agreements allow all state agencies, as well as the University of California, California State University, the Community Colleges, and local governments, to lease ZEVs according to pre-defined and pre-approved terms, conditions and lease rates. This greatly simplifies the leasing process and allows for more rapid acquisition of vehicles. Additional Master Service Agreement with DaimlerChrysler Corporation (for the EPIC) and Nissan (for the Altra EV) are currently being developed.

As of May 2000, 28 different state and local agencies have leased or committed to lease more than 100 vehicles under these Master Service Agreements and prior agreements. These numbers are expanding rapidly due to the ***ev Sacramento*** program, discussed in Section 3.3.1.2 below. Leases or commitments have been made by the following:

- Department of General Services
- Department of Water Resources
- Department of Forestry and Fire Protection
- Department of Justice
- Department of Parks and Recreation
- Department of Food and Agriculture
- Department of Toxic Substances Control
- Department of Social Services
- Cal/EPA
- Air Resources Board
- Integrated Waste Management Board
- California Energy Commission
- California Highway Patrol
- CalTrans
- Bureau of Automotive Repair
- Office of State Printing
- Franchise Tax Board
- California Exposition and State Fair
- University of California, Davis
- University of California, Los Angeles
- California State University, Chico
- Sacramento County
- City of Sacramento
- City of Citrus Heights
- Sacramento Metropolitan Air Quality Management District
- Sacramento Metropolitan Airport
- Sacramento Public Library

These totals do not include a large number of local agencies that have leased ZEVs using mechanisms other than the state Master Service Agreement.

The ARB and other state and local agencies have undertaken other activities to further encourage ZEV leasing, such as the following:

3.3.1.1 The EV Loan Program

To encourage the use of EVs in public fleets and address its obligation under the MOAs, the ARB designed a three-year program to loan EVs at no cost to federal, state and local government agencies. The South Coast Air Quality Management District provides financial support for the operation of the program within its jurisdiction. The Department of General Services (DGS) assists with housing, maintaining and dispatching the loan program EV fleet.

The goals of the EV Loan Program are to encourage EV leasing by providing public agencies with a no-risk opportunity to see if electric vehicles meet agency needs, familiarize senior officials with vehicle capabilities, and publicize the availability of electric vehicles to governmental agencies and to the public at large.

The loan fleet includes fifteen vehicles--four GM EV1 vehicles with lead acid batteries, six Honda EV Plus vehicles with nickel metal hydride batteries, and five Ford Ranger pickups with nickel metal hydride batteries. Seven additional vehicles (two Chevrolet S10 pickups and five Toyota RAV4 vehicles, all with nickel metal hydride batteries) have been ordered to expand the program.

The EV Loan Program began operation on a pilot basis in Sacramento in March 1998, using one Honda EV Plus that was provided by the DGS. The loan program's own vehicles were delivered in June 1998 (EV Plus), August 1998 (EV1), and January 1999 (Ford Ranger). The program expanded to Los Angeles in September 1998, the Bay Area in October 1998, and San Diego in April 1999.

As of May 2000, there have been one hundred and twenty-one loans completed. Loan durations ranged from several days to three months, but the majority were one month. Fifteen loans are in progress, and thirteen additional agencies are waiting to participate. Forty-three vehicles have been leased as a result of the program, and several agencies are considering leases but have not yet made a final decision.

The EV Loan Program is a large-scale effort to provide public agency managers the opportunity to drive EVs. The program has demonstrated that public agencies, when given real-world experience with EVs, often find that the vehicles provide an environmentally sound way to meet many of their fleet needs. The agencies have been able to develop a good understanding of EV range, reliability, operating and maintenance costs, infrastructure requirements, and other data needed to make informed leasing decisions, both now and in the future.

3.3.1.2 Department of General Services Outreach

The Department of General Services, Office of Fleet Administration, has an aggressive program in place to encourage state agencies to lease electric vehicles. In addition to its support for the EV loan program described above, the Department:

- Provides free daily use of EVs through the state vehicle pool fleet
- Provides ride and drive opportunities to state executives
- Provides flexible lease terms with no-penalty cancellation provisions

- Sends letters to state fleet managers and Business Services Officers outlining EV availability
- Showcases EVs at numerous conferences and other events
- Participates in the national Clean Cities program
- Maintains a web site providing information on EV options

3.3.1.3 ev Sacramento

Many California public agencies are already using electric vehicles. EVs are being driven by agency administrators, field and technical staff, and have been incorporated into a variety of public programs. One barrier that has hindered public agencies in acquiring electric vehicles, however, has been their higher initial cost when compared to their conventionally fueled counterparts.

ARB is committed to increasing the use of EVs by State agencies, and initiated ***ev Sacramento*** to assist with this commitment. The goal of ***ev Sacramento*** is to assist State and local public agencies in the Sacramento region to lease EVs at competitive prices. By offsetting the initial higher costs of these vehicles, this program will significantly expand the use of EVs in the Sacramento area.

The program is jointly administered by the ARB and the Department of General Services Office of Fleet Administration. ***ev Sacramento*** is a three-year program, and includes most of the EVs that are now commercially available. The vehicles that are available through the program include the GM EV1, Toyota RAV4 EV, Ford Ranger, Chevrolet S10, and the Honda EV Plus. Program staff is also working with Nissan to include the Altra in the program. The majority of vehicles will be placed in the second quarter of 2000.

State and local agencies in the Sacramento area are eligible to participate. Participants pay reduced lease payments that are comparable to lease rates for conventional vehicles. In addition, ***ev Sacramento*** staff coordinate the delivery of the vehicles and the installation of charging infrastructure, and provide all training and user support.

As of May 2000, 19 state and local agencies have committed to lease 94 vehicles under the program, on target to an eventual goal of more than 100 vehicles.

3.3.1.4 State Budget Initiatives

Each year, the state Budget Act appropriates funds from the Petroleum Violation Escrow Account (PVEA) to support a variety of energy and transportation projects. Portions of this funding have been used to subsidize the purchase of electric vehicles and infrastructure by local agencies.

The 2000-2001 proposed Governor's Budget requests significant funding from the Petroleum Violation Escrow Account and the General Fund for electric and alternative fuel vehicles, incentives and infrastructure. Highlights include:

- $5 million for the Air Resources Board to participate in the Fuel Cell Partnership
- $6 million for the California Energy Commission to establish a clean fuels infrastructure for public agencies
- $5 million for the California Energy Commission to establish the Vehicle Efficiency Incentive program to provide incentives for the lease or purchase of electric, hybrid electric, and fuel cell vehicles
- $1 million for the California Energy Commission to develop a hydrogen fuel infrastructure as part of the Fuel Cell Partnership
- $0.5 million for the California Energy Commission to study issues affecting hydrogen fueling infrastructure
- $4 million for the Department of General Services to purchase alternative fuel vehicles for the state vehicle fleet

3.3.2 Insurance

The ARB is required to work with the California Department of Insurance to establish reasonable rates for insuring new ZEVs, to promote insurance industry awareness of ZEVs, and to resolve other issues related to insuring ZEVs.

ARB staff and Department of Insurance staff are not aware of any insurance issues that have arisen with the market-based launch of EVs over three years ago. The EV user has had little difficulty obtaining necessary insurance. At least one manufacturer, Honda, includes comprehensive and collision insurance in the lease package. For drivers of other EV models, the insurance experience appears to have been smooth, with comparable coverage and rates available including second car discounts. On occasion, the EV user may need to spend additional time in the process if the insurer has not had experience writing a policy for an EV.

Based on an informal ARB staff survey of retail EV users in California, it appears that insurance for EVs is available from virtually every insurance company licensed to do business in California. Staff also met with a local insurance broker, who represents a larger company, to discuss the process for establishing the insurance rate for an EV. The broker indicated that the process is identical to that used for any vehicle on the market. With the make and model in hand, the broker looks up a vehicle's "insurance rating group" (IRG). Vehicles with similar characteristics, (e.g., replacement and repair costs, typical damage, and model year) may be placed in the same IRG. If a vehicle has not been assigned to an IRG, or is a new model or model year not covered by an IRG, the industry standard practice is to calculate a rate based on the manufacturer's suggested retail price (MSRP). The broker visited by staff had an IRG manual that contained specific instructions for EV rates to be calculated using the MSRP.

As no significant insurance issues have arisen with the market-based launch, ARB staff concludes that insurance issues will not present obstacles to further expansion of the EV market. Staff will, however, continue to monitor insurance availability for EVs as the market grows.

3.3.3 Financing

The ARB is required to work with the California Department of State Banking to develop risk assessment data to assist in securing financing for the purchase or lease of ZEVs.

To date, financing issues have not presented obstacles to further expansion of the EV market. Financing has not presented a problem for retail consumers because to date the vehicles are primarily leased rather than purchased. The decision to lease EVs to consumers rather than sell the vehicles has not been based on concerns about financing availability. Rather, the auto manufacturers have indicated that offering lease programs to consumers protects customers from risks associated with investing in new, quickly changing technology. ARB staff will continue to monitor these areas to ensure that any future issues that arise are dealt with in a timely manner.

3.3.4 Battery Recycling

The MOA directed the ARB to work with the Department of Toxic Substances Control, the Integrated Waste Management Board, and the Office of Environmental Health Hazard Assessment to ensure the availability of sufficient battery recycling capacity.

To address issues related to EV battery disposal and recycling, the ARB contracted with ARCADIS Geraghty & Miller in 1994. This contract work was broken into two main tasks. First, the contractor evaluated battery technologies based on their performance and recyclability. This work was completed in March of 1995. In addition to determining where efforts should be focused in establishing new recycling facilities and developing cleaner technologies, task one recommended that a deposit of between $100 to $150 be levied on light-duty vehicle batteries to ensure they are returned for recycling.

Task two compared the relative health and hazard impacts from EV battery recycling technology, and was completed in April of 1999. The main focus of task two was to compare the relative impact of recycling EV batteries in terms of cancer, toxicity, and ecotoxicological potential, as well as leachability, flammability, and corrosivity hazards. These impacts were evaluated for recycling methods, including smelting, electrowinnowing, and other appropriate techniques that apply to different battery technologies. A multi-attribute impact analysis was performed on the health and hazard effects resulting from the recycling and disposal of each battery type. The methodology used a semiqualitative ranking to weight the relative impact and establish a health and environmental impact score for each battery type.

Due to the substantial uncertainties surrounding the analyses, the methodology is designed for comparison purposes only. While current battery constituents are fairly well known, they do vary with manufacturer and are likely to change in the future. In addition, there are substantial uncertainties surrounding the health impact values and future recycling technologies. With this said, a broad conclusion of the analysis is that the more advanced batteries expected to be used in larger commercial quantities in the 2003 timeframe represent a great improvement over conventional lead-acid batteries, both in terms of battery performance and impacts from recycling spent batteries.

In addition to this contract work, ARB staff has also followed battery recycling issues at the national level by participating on the Department of Energy's Advanced Battery Readiness Working Committee. One of the Committee's main activities is to address issues related to EV battery disposal and to review progress made in developing new recycling methods for advanced batteries.

At this time, there do not appear to be any overwhelming obstacles to recycling the battery technologies expected in the 2003 timeframe. Currently, there is one facility in the United States capable of recycling nickel-based batteries. Another plant in Canada is now successfully recycling large military lithium-based batteries. While recycling technologies are being developed and are expected to be in place, it will be necessary to build new recycling plants for certain battery types, such as lithium-ion, to accommodate their use in large quantities. Any new recycling facilities would be required to meet stringent air quality and environmental regulations that would minimize any adverse effects of the recycling processes.

3.3.5 Assist Local Governments with Public Infrastructure

The MOA requires the ARB to work with local governments to provide assistance in planning and permitting quick charge and public charging stations. ARB has worked with utilities and electric vehicle infrastructure providers to assess charging station implementation issues and ensure that convenience-charging facilities are developed as needed. The California Energy Commission, ARB and other government agencies, and the automakers have also assisted with modification and adoption of electrical and building codes that address the needs of charging stations. This group instigated and coordinated the development of training for building officials involved with permitting and inspection of infrastructure installations.

The current status of public infrastructure is discussed in more detail in Section 6.2 below.

3.3.6 Training for Installation and Maintenance of EV Charging Stations

The MOAs directed ARB to work with utilities and trade groups representing electrical contractors to provide training for installation and maintenance of electric vehicle charging systems.

To address issues associated with installation of EV chargers, especially related to building codes, electrical codes and training of permitting and inspection personnel, the California Energy Commission formed the Building Codes Working Group. The Building Codes Working Group included the Energy Commission, the ARB, the California Building Officials, the California Electric Transportation Coalition, California utilities, General Motors, and Hughes Power Systems. The Building Codes Working Group developed revisions to the California Building Standards to allow for safe installation of electric vehicle charging systems. The Building Code changes, effective in 1996, defined EV charging equipment, added safety requirements, clarified the definition of refueling, and added ventilation requirements. The Building Codes Working Group also modified the California Electric Code to include a requirement to use approved or UL listed EV charging equipment.

In an effort to provide a national standard for building code requirements related to EV charging systems, the Building Code Working Group focused much of its efforts through 1997 on preparing modifications to the National Electric Code. Changes suggested by the Building Code Working Group were forwarded to the National Infrastructure Working Council for approval and submittal to the National Electric Code governing organization.

Following adoption of the California code revisions, a training program was developed for building officials, which covered the following:

- The new Building Code and Electric Code provisions governing EVs;
- Plan check and inspection techniques for the new regulation;
- An overview of current and emerging EV technologies including automotive, batteries and charging equipment;
- An opportunity to see and drive current production vehicles; and
- Hands-on experience with charging system equipment.

Additional activities of the Building Code Working Group included development of Interim Disabled Access Guidelines for Electric Vehicle Charging Stations in cooperation with the State Architect. Since EV charging stations are offered as a service to the general public, they are required to be accessible to those with disabilities. The guidelines give potential public infrastructure providers guidance on making installations accessible to those with disabilities.

The final project undertaken by the Building Code Working Group was the development of an informational brochure for building officials, contractors and consumers. The brochure provides information about permitting and inspection requirements, cites appropriate building and electric codes and gives phone numbers for agencies that can provide further information.

3.3.7 Support Efforts of National Infrastructure Working Council

ARB is required to support the Infrastructure Working Council's efforts on standardization of power supply, emergency disconnect, and standard conductive and inductive charging systems.

ARB staff has attended the Infrastructure Working Council's meetings, observing and participating in the Health and Safety Committee, the Connector and Connecting Stations Committee and the Connector Standardization Subcommittee of the Bus and Non-Road Committee. ARB's participation in the Health and Safety Committee has been focused on assistance with the proposed modification of the National Electric Code. ARB and California Energy Commission staff have observed and provided comments to the Connector and Connecting Stations Committee. This Committee, in turn, provided input to the Society of Automotive Engineers, which adopted a single standard for the butt-type conductive connector used by Honda and Ford. ARB staff has also observed the early work of the Bus and Non-Road Committee and has been asked to participate in the Connector Standardization Subcommittee as it works to determine the need for connector standardization for buses and non-road vehicles.

3.3.8 Training Programs for Emergency Response

ARB is required to work with the State Fire Marshal and other state and local emergency response officials and towing companies to create a comprehensive training program to ensure preparedness for incidents involving EVs.

Similar to the Building Code Working Group, the California Energy Commission formed the Emergency Response Working Group with ARB, the California Office of the State Fire Marshal, the California Highway Patrol, utilities, auto manufacturers and industry organizations such as the California Electric Transportation Coalition. The purpose of the working group was to develop training designed to inform emergency response personnel about EVs and the differences in response procedures for incidents involving EVs.

In 1998, the Emergency Response Working Group completed the development of a training program consisting of material to train instructors, an instructor's manual and compact disc, and slide teaching materials and student manuals. Train-the-trainer courses have been held throughout the state. Through the Infrastructure Working Council, the complete package of training materials has been distributed to every state Fire Marshal Office in the United States.

3.3.9 Observe Activities of the U.S. Advanced Battery Consortium (USABC)

The MOAs require ARB to maintain its commitment to observe the activities of the United States Advanced Battery Consortium (USABC) regarding the development of advanced technology batteries. The mission of the USABC is to pursue research and development of advanced energy systems capable of providing future generations of electric vehicles with significantly increased range and performance. The USABC has defined Mid-Term, Intermediate-Term ("Commercialization") and Long-Term criteria that set forth increasingly stringent goals for acceptable electric vehicle performance and economics. Now widely accepted as goals for ongoing development, these criteria are viewed by the USABC as the minimum standards that must be met if EVs are to be acceptable to a significant percentage of vehicle users.

Through the USABC, the three large U.S. vehicle manufacturers are committed to development of advanced batteries in keeping with their MOA obligation. ARB staff continues to attend the USABC Technical Advisory Committee (TAC) meetings on a quarterly basis. By attending these meetings, ARB staff is able to monitor the progress of USABC contracts with various developers and gain insight as to the contractors' progress. While much of the information obtained is confidential, the following provides a general overview of current USABC activities and developments.

The USABC completed its developmental efforts for Mid-Term battery technologies in 1999. The SAFT nickel-metal hydride (NiMH) and Ovonic Battery Company (OBC) NiMH technologies successfully demonstrated improvements in battery performance, cycle life, and cost reduction. For example, compared to the USABC Mid-Term goals of 80 Whr/kg, 150 W/kg, and 1,000 cycle life, both developers have achieved at least 70 Whr/kg, 150 W/kg, and 800 cycles. In fact, the SAFT technology has realized a cycle life well in excess of 1,000 cycles. OBC continues to make progress towards achieving a 100 Whr/kg EV battery design. For hybrid applications, where power is of greater importance than energy, OBC has achieved specific power levels surpassing 750 W/kg. While the cost of each NiMH technology is currently more than twice the USABC Mid-Term goal of $150/Kwhr, both manufacturers have successfully reduced production cost by over 25 percent during the last two years.

Current USABC programs are focused on long-term battery technologies and meeting the USABC Long-Term and Commercialization goals. Two major contracts are currently in place investigating lithium-based battery technologies. The SAFT Lithium-Ion contract is currently in Phase I of the development process and is primarily focused on cell and module optimization. The Lithium-Polymer contract is also at the development phase with promise to offer a safe and cost effective battery technology within the next five years. These lithium-based technologies are expected to achieve specific energies well in excess of

100 Whr/kg. Improved specific power of greater than 200 W/kg and a cycle life of more than 600 are also expected. The key characteristic of battery cost should also benefit from these two technologies.

The USABC is expected to initiate a Phase III program this year. Phase III funding will be approximately $62 million and span a total of four years. USABC has indicated that those technologies capable of realizing the long-term goals will be considered.

3.3.10 Reasonable Incentives

Under the MOAs, ARB must support the development and implementation of reasonable incentive programs that enhance the near-term marketability of ZEVs. Because ZEVs are a relatively new technology and are currently produced in limited quantities, they are more expensive than conventional vehicles. To enhance vehicle marketability in the near term and to assist in the transition to large volume production, it is vital to provide support, both monetary and non-monetary, in the form of vehicle and infrastructure incentives.

Where possible, the ARB and other state agencies have supported the development and implementation of various incentive programs. The California Energy Commission has continued to support vehicle buy-down programs at the district level and has recently provided matching funds for the development of EV infrastructure. Recent legislation authored by Assembly Member Cuneen and signed by Governor Davis allows single occupant vehicles with “inherently low emissions” (ZEVs, as well as vehicles using alternative fuels, with extremely low tailpipe emissions and zero evaporative emissions) to use high occupancy vehicle lanes.

The following list provides an example of the federal, state, local and private incentive programs currently available.

3.3.10.1 Federal Incentives

- Tax credit for 10 percent of the cost of an EV, up to $4,000, through 2004.
- Business tax deduction of $100,000 for electric recharging sites.
- The Energy Policy Act of 1992 includes a ten year $50 million EV demonstration program and a fifteen year $40 million cooperative program between government and industry to research, develop and demonstrate EV infrastructure.
- Elimination of the luxury tax for alternative-fueled vehicles.

3.3.10.2 State of California Incentives

- Up to $5,000 of the incremental cost of a ZEV for fleets located in Clean Cities regions (Bay Area, Orange, Riverside, Sacramento, San Bernardino, San Diego, Santa Barbara, Ventura and Yolo-Solano) provided by California Energy Commission and the U. S. Department of Energy.

- CEC funds support the installation of EV charging infrastructure by new purchaser or lessee.
- PVEA funds are made available to local governments to support the lease of alternative fuel vehicles.

3.3.10.3 Local Incentives

- The Bay Area Air Quality Management District “Charge!” program offers grants to subsidize installation of public EV charging stations. To date $150,000 has been awarded for 26 sites, and additional funds are available.
- The Bay Area Air Quality Management District offers $5,000 buydown incentives for EVs to both private individuals and private fleets, and to public agencies.
- The Mobile Source Reduction Committee of the South Coast Air Quality Management District offers public and private customers a $5,000 rebate per EV purchased or leased.
- In conjunction with the CEC, several Air Pollution Control Districts offer $5,000 for the purchase or lease of EVs for public and private customers.
- The Los Angeles Airport offers free parking and charging for EVs in its Central Terminal Area. Charging stations were installed at the Los Angeles Airports as part of the Quick Charge Los Angeles EV program.
- The City of Sacramento offers free EV parking and charging at city garages.
- The City of San Francisco is installing EV charging at city garages.

3.3.10.4 Utility Incentives

- The Los Angeles Department of Water and Power, Sacramento Municipal Utility District, Pacific Gas and Electric Company and Southern California Edison all provide discounts for off-peak recharging of EVs to retail EV customers. These discounts typically result in at least a fifty percent reduction in the cost of charging, with rates around 5 cents per kilowatt-hour.
- San Diego Gas and Electric offers a discount rate for electricity used to recharge EVs during off-peak time periods as well as $50,000 in seed money to help local businesses and governments install charging stations in its service area.

In addition to these incentives, the ARB has been working cooperatively with government agencies, auto manufacturers and other stakeholders to determine the most effective way to support the introduction of ZEVs into the marketplace. New monetary as well as non-monetary incentives have been discussed in addition to possible extensions of the incentives that currently exist. Many of these existing incentives were put into place prior to the 1996 amendments to the ZEV program and it would be appropriate to extend them to foster the commercialization of ZEVs during the market-based introductory period.

3.4 Additional ARB Activities

ARB has instigated or been involved in a number of outreach programs, events and research contracts in addition to those addressed in the MOAs. Board members and staff have participated in local outreach as well as attended conferences and exhibitions promoting the use of zero-emission vehicles.

3.4.1 ARB Test Fleet

The ARB has acquired a test fleet of EVs, with three GM S-10s, three GM EV1s, and two Honda EV PLUS vehicles. In an effort to gather information about the vehicles, their usage patterns, and issues associated with everyday EV use, ARB has set up a system to allow ARB employees to use the vehicles for between two days and a week. Employees are encouraged to do outreach to schools and other local groups. Participating employees are given a specific vehicle to drive for a week or a weekend and are encouraged to use the vehicle for as much of their normal driving as possible. Employees are then required to fill out a log that indicates usage pattern and any suggestions regarding vehicle usability and accessibility. This system has been very successful and gives ARB and users the opportunity to gain valuable experience with EVs and infrastructure. Based on discussions with employees and entries in the EV logbooks, these experiences are typically very positive and users find that the vehicle meets practically all their driving needs.

ARB staff have also driven a wide range of other vehicles to learn first hand about their operating characteristics.

3.4.2 EV Rental Demonstration Program

The ARB and the South Coast Air Quality Management District (SCAQMD) are working together to support an electric vehicle rental demonstration program. This program will provide high visibility and convenient availability of EVs. The EV Rental Demonstration has the following objectives:

- Establish a successful EV rental program that will give a large number of the general public and government employees the opportunity to experience the benefits and attributes of EVs.
- Provide positive image of EVs for public and policy makers.
- Gain valuable information regarding the use of EVs in rental car fleets.
- Provide clean air benefits in those areas renting the EVs.

EV Rental Cars L.L.C. was chosen through a competitive bidding process to conduct the EV Rental Demonstration program. EV Rental Cars is working jointly with Budget Rent-a-Car to rent EVs. In addition to the Los Angeles International Airport location, which opened in December 1998, and the Sacramento International Airport location, which opened in August 1999, the program will expand to five additional Budget Rent-a-Car locations:

- Burbank Airport
- John Wayne Airport in Orange County
- Ontario International Airport
- Downtown Sacramento
- Beverly Hills

The ARB is providing $100,000 to co-fund this program and 5 Honda EV Plus vehicles. The SCAQMD is providing $200,000. In addition, EV Rental Cars and the other subcontractors involved in the program will cost-share by contributing $252,000 in cash and $523,755 in-kind to this project. These subcontractors include SMUD, the City of Burbank, the City of Anaheim, the Los Angeles Department of Water and Power, and Southern California Edison.

3.4.3 EV Long-Term Placement Program

The Honda Motor Company provided funding for Supplemental Emission Projects, as part of a Settlement Decree with ARB. The Supplemental Emission Projects include the Electric Vehicle Long Term Placement Program, under which 25 Honda EV Plus electric vehicles have been made available to public agencies for long-term loans (6 months to one year). The goals of the Electric Vehicle Long Term Placement Program are to promote greater awareness of electric vehicles among the public, familiarize senior public and private officials with electric vehicles and their capabilities, and encourage the leasing of electric vehicles by public agencies.

The Electric Vehicle Long Term Placement Program is a three-year program, now in its first year of operation. Vehicles have been placed with a variety of public agencies:

- Yosemite National Park (2 vehicles)
- State Parks in Sacramento and San Diego (1 vehicle each)
- Griffith Park, Los Angeles
- San Joaquin Valley Air Quality Management District
- Sacramento Metropolitan Air Quality Management District
- Ventura County Air Pollution Control District
- Yolo-Solano Air Pollution Control District
- Resources Agency Secretary
- Trade and Commerce Agency Secretary
- EV Loan Program, Bay Area (2 vehicles) and San Diego (1 vehicle)
- DGS State Garage Daily Rental
- ARB vehicle fleet (4 vehicles)
- EV Rental Fleet (5 vehicles)

Agencies that have received vehicles will provide a brief report at the end of the placement. The report will summarize the accomplishments of the program, identify activities in which the vehicle was used, and note any problems that occurred. This data will provide on-going information by which to evaluate the effectiveness of the program, as well as track any vehicle or charging problems that may have occurred. After agencies have concluded their loans, ARB staff will solicit new participants for the program.

3.4.4 Participation in Conferences and Exhibitions

ARB has participated in a number of conferences and exhibitions including the North American Electric Vehicle Infrastructure Conference, several international Electric Vehicle Symposia, the World Electric Vehicle Expo, the Los Angeles International Auto Show, and various Clean Cities Conferences. ARB has attended, contributed papers and/or purchased booth space at these and other gatherings. In addition, Board members and staff have participated in ride and drive programs, public relations events and technical advisory groups.

3.4.5 Outreach Events

Board members and staff have been very proactive in conducting public outreach to schools, community events, and community groups. These outreach events have been very successful at a "grass-roots" level. Often, a Board or staff member is accompanied by a member of the Zero-Emission Vehicle Implementation Section who may give a presentation or participate in a demonstration of the vehicle.

Over the past twelve months, ARB staff using vehicles from the ARB test fleet have participated in thirty-four outreach events at schools and more than twenty other events at youth groups, fairs, Earth Day celebrations, and other similar locations. Over the same time period staff from the ZEV implementation Section participated in an additional sixteen events including Science Day at the State Capitol, Clean Air Day, and the Los Angeles International Auto Show. These events provide participants with an opportunity to gain experience with new vehicle technology and have questions answered about EV capabilities.

4 VEHICLE TECHNOLOGY ASSESSMENT

4.1 Introduction

In June 1999, ARB began meeting with auto manufacturers to discuss their obligations and plans for meeting the ZEV requirement in MY 2003. In December 1999 and February 2000, ARB staff visited all the large volume manufacturers in Japan and in the US to examine, first hand, the progress each manufacturer is making in preparing to meet the ZEV requirement as detailed in their product plans. Prior to the site visits, each manufacturer had provided ARB staff with product plans describing in detail how they intend to meet the MY 2003 ZEV requirement. The product plans included information regarding key development stages, decision points, and other milestones. In addition, the site visits provided ARB staff with a chance to examine prototypes of various types of advanced vehicle technologies.

This chapter discusses the development status of “pure” zero emission vehicles, and “full” and “partial” ZEV allowance vehicles. It concludes with a discussion of new categories of vehicles such as city and neighborhood electric vehicles. These latter vehicles are discussed separately because they have different operating characteristics than full range vehicles and are intended to fill different market segments.

4.2 Pure ZEV Vehicles

This section evaluates the progress made to date in developing “pure” zero-emission vehicles--vehicles having no direct emissions. Vehicles can be certified as ZEVs if they produce zero exhaust emissions of any criteria pollutant (or precursor pollutant) under any and all possible operational modes and conditions. These vehicles do, of course, result in a small amount of indirect emissions at stationary sources such as power plants or hydrogen production facilities due to the generation of electricity or hydrogen for use on board the vehicle. In the discussion of vehicle emissions (Section 9) the indirect emissions and environmental impacts from these stationary sources will be quantified in order to allow a meaningful comparison to other vehicle technologies.

Pure zero-emission vehicles hold distinct air quality advantages over technologies that use a conventional fuel such as gasoline in a combustion engine. Vehicles with combustion engines inevitably exhibit deterioration that results in increased emission levels as the vehicle ages. They are also subject to becoming gross polluters if critical emission control systems fail. High volatility liquid fuels such as gasoline are responsible for significant fuel cycle emissions. For all of these reasons, vehicles with no potential to produce emissions are the “gold standard” of even the cleanest, most advanced new technologies.

From the inception of the ZEV program, the battery electric vehicle has been the leading candidate for meeting the ZEV percentage requirements due to its stage of commercial development. Since 1990, worldwide effort in the research and development of vehicle and battery technology has greatly improved the prospects for the successful commercialization of electric vehicles. More recently, fuel cell technology has gained worldwide attention as a technology capable of supplanting current internal combustion engine vehicles in the market while providing zero direct emissions (when using stored hydrogen). The following sections provide a summary of the developmental status and infrastructure needs for these two technologies.

4.2.1 Battery Electric Vehicles

Battery electric vehicles were first commercialized more than one hundred years ago. After giving way to gasoline vehicles in the first part of this century, several efforts were made in the 1960's and 1970's to reintroduce and commercialize the technology. While the basic concept of today's electric vehicle remains the same, significant advances in components and vehicle technology have provided new opportunities for the use of electric drive in passenger vehicles.

4.2.1.1 Description of Technology

Battery electric vehicles use an electrochemical battery to store energy. In addition to this energy source, an electric vehicle employs an electric powertrain that includes a motor and controller. Electric vehicles use one of three different types of electric motors: DC (both series and shunt), AC-induction, and permanent magnet DC-brushless. Controllers used with these motors are usually either solid-state electronic, pulsed-width modulation with power transistors, or insulated gate bipolar transistors. Other components include the battery management system, battery charger, state-of-charge meter, charging connector, and electronic protection devices.

4.2.1.2 Development Status

Historically, the inability of batteries to store sufficient energy at a reasonable cost has limited the market for battery electric vehicles. However, considerable advances in the last ten years in component technology have greatly improved overall vehicle efficiency and thus range. By improving the efficiency of drivetrain components and integrating the operation of the battery and drive train under normal operating conditions, EVs currently available can deliver nearly three times the range of EVs from the 1970's having the same amount of stored energy. Just as important, these advances have also included new designs that are projected to be cost comparable to the internal combustion engine vehicle in large volume production (not including the battery). The improved efficiency has been achieved in large part due to the improvements in efficiency of each component mentioned above and through the integrated operation of battery and drivetrain under normal vehicle operating conditions.

Because battery technology is the critical component in a battery electric vehicle, the ARB has contracted with four experts in battery technology to closely evaluate the state of development and cost issues of advanced batteries.

4.2.2 Fuel Cell Vehicles

Fuel cells are electrochemical devices that allow for the conversion of chemical energy of fuels directly into electricity. By doing so, the technology avoids the loss of efficiency and emissions of air pollutants that occur with the use of combustion-based engines. While originally discovered in 1839, the first practical use of the technology occurred during the early years of the manned space program in the 1960’s. Subsequent manned space efforts, up to and including the Space Shuttle program, have continued to rely upon fuel cells for electric power. This success, in turn, has resulted in large efforts and investments in the technology to develop fuel cell technology for both stationary and mobile applications.

More focused efforts to develop the technology for transportation have resulted in significant improvements in the core technology. The key motivations for this recent interest include concern over urban pollution, a need for alternatives to a diminishing oil supply, and growing concern over global climate change due to carbon dioxide emissions from mobile sources. Because fuel cells are powered by alternative fuels, and operate at high efficiency, fuel cell vehicles can help achieve both energy efficiency and energy diversity goals. A fuel cell vehicle can either store hydrogen or obtain hydrogen through the reformation of an alternative fuel.

4.2.2.1 Description of Technology

While there are several different fuel cell technologies available for use in vehicles, the leading candidate for automotive application is the proton exchange membrane (PEM). Simply described, a fuel cell consists of a membrane, two electrodes, and gas chambers. In acid electrolyte, hydrogen reacts at the electrode, giving up electrons while hydrogen ions are passed through the electrolyte. The electrons are used to operate an electric motor that can then propel the vehicle. After transferring to the cathode side, the hydrogen ions combine with oxygen (typically from the air) and the electrons that have produced work, to form water. Since no combustion is involved, water is the only product from the process. Many of the same components needed by a battery electric vehicle (e.g. the electric power train) are also necessary in a fuel cell electric vehicle.

4.2.2.2 Development Status

In 1998, the ARB contracted with a Panel of experts in fuel cell technology to assess the current status of fuel cells for transportation applications. According to the Panel's review of the technology, significant advances in fuel cell stack technology in recent years have overcome the technical barriers to attaining the performance needed for fuel cell electric vehicle engines.

Efforts are now ongoing worldwide to integrate the latest fuel cell designs into fuel cell engines, and ultimately fuel cell electric vehicles. The biggest challenge now facing automakers is to package the necessary hardware and reduce the cost of the technology to a level comparable to the internal combustion engine. Based on recent visits to manufacturer research and development facilities, however, staff concludes that mass production fuel cell vehicles will not be available until beyond 2003.

Manufacturers continue to advance the state of fuel cell technology. For example, recent news reports have described:

- Significant improvement in fuel cell stack performance under freezing conditions
- Development of next generation stacks that provide higher power while reducing system size and weight
- Introduction of new prototype vehicles by DaimlerChrysler, Ford (Th!nk) and General Motors
- Development of advanced fuel system technologies
- Groundbreaking for the headquarters and associated support facilities for the California Fuel Cell Partnership

The availability projection noted above applies to for fuel cell vehicles that reform (or extract hydrogen from) a fuel such as methanol on board the vehicle. The operation of a reformer, however, results in ozone precursor emissions. Thus, to achieve zero direct emissions the vehicle has to store hydrogen on board the vehicle. While this greatly simplifies the vehicle's design (e.g. no reformer), it raises new issues regarding the storage of sufficient quantities of hydrogen on the vehicle. The storage of hydrogen, even at fairly high compression (e.g. 5,000 psi), requires roughly 10 times the volume that is needed for the storage of an equivalent amount of energy in gasoline form. Because the fuel efficiency of a fuel cell is significantly higher than that of an internal combustion engine, less fuel is needed to go a given distance. Nevertheless, passenger cars are not currently able to accommodate enough hydrogen for adequate range without seriously compromising the passenger and cargo space.

Manufacturers have explored options that include storing the hydrogen in low-temperature liquid form, or bound chemically to a metal alloy. Efforts continue, but the potential for breakthroughs in hydrogen storage remains uncertain. While a hydrogen fuel cell vehicle is believed to be the best long-term approach, its commercial introduction is not expected until beyond 2003. As part of research and development of fuel cell vehicles, automakers will demonstrate passenger cars using stored hydrogen in liquid form. The goal is not to demonstrate the commercial feasibility of this design, but rather to test, evaluate and refine all aspects of the fuel cell stack and engine.

To address fuel cell vehicle and infrastructure issues, in April 1999 California Governor Gray Davis and industry leaders announced a fuel cell vehicle partnership that will demonstrate clean transportation technology on California's roadways in the future. The "California Fuel Cell Partnership - Driving the Future" makes the state home to a unique collaboration of auto manufacturers (DaimlerChrysler, Ford, Honda, Nissan, Volkswagen), energy providers (BP Amoco [formerly ARCO], Shell Hydrogen, Texaco), a fuel cell company (Ballard Power Systems), the State of California (Air Resources Board, California Energy Commission), the South Coast Air Quality Management District, and the United States Department of Energy. Associate partners, who bring specific expertise to aid in fuel, vehicle and bus demonstration activities, include Air Products and Chemicals, Inc., Linde AG, Praxair, Methanex, the Alameda-Contra Costa Transit District, and the SunLine Transit Agency.

The Partnership will demonstrate fuel cell powered electric vehicles under real day-to-day driving conditions. The Partnership will place about 50 fuel cell passenger cars and fuel cell buses on the road between 2000 and 2003.
In April 2000 the Partnership formally signaled the start of construction for a fuel cell vehicle headquarters facility in West Sacramento with a groundbreaking ceremony. The facility, which will house fuel cell electric vehicles and a hydrogen refueling station, will serve as an operations base for executing the Partnership's goals of demonstrating fuel cell vehicle technology and an alternative fuel infrastructure over the next four years. The 55,000 square-foot, state-of-the-art facility is expected to open in autumn 2000.

4.3 Full and Partial ZEV Allowance Vehicles

In 1998 the ARB modified the ZEV requirement to allow ZEV credit to be earned by vehicles with near-zero emissions. This section discusses the development status of such vehicles.

4.3.1 Definitions and Requirements

Under LEV II, “near-zero” emission vehicles may qualify to earn a ZEV allowance of between 0.2 and 1.0 per vehicle. Vehicles that qualify for a ZEV allowance of 1.0 are known as full ZEV allowance vehicles. Vehicles that qualify for a ZEV allowance of between 0.2 and 1.0 are known as partial ZEV allowance vehicles (PZEVs). Staff believes that this ZEV allowance approach towards satisfying the

ZEV requirement will promote the continued development of battery-powered electric and zero-emitting fuel cell vehicles, while encouraging the development of other advanced technology vehicles that have the potential for producing extremely low emissions. Manufacturers will be able to decide which mix of vehicles makes the most technological and economic sense based on their own strengths in each area.

Large automakers must meet at least 40 percent of their ZEV requirement with pure ZEVs, full ZEV allowance vehicles, or credits generated by either of these vehicle types. They may meet the remaining 60 percent of their overall ZEV requirement with PZEV vehicles earning ZEV allowances of less than one.

To earn a ZEV allowance for a vehicle, the manufacturer must, at a minimum, meet the following baseline PZEV requirements:

- Certify vehicle to 150,000 mile SULEV emission standards
- Certify vehicle to zero evaporative emission standards
- Certify vehicle to meet OBD II requirements for the life of the vehicle, and
- Extend performance and defects warranty to 15 years/ 150,000 miles

One important advantage of battery and hydrogen fuel cell electric vehicles is that their “tailpipe” emissions do not increase when their components fail and are in need of repair. The extended warranty requirement for PZEVs is a very important element of LEV II and is intended to address this issue. It requires manufacturers to provide a 150,000 mile emission warranty under which all malfunctions identified by the vehicle’s OBD II system will be repaired under warranty for a period of 15 years or 150,000 miles (whichever occurs first). This warranty is necessary to ensure that vehicles receiving credit for near zero emissions are able to maintain this performance throughout the useful life of the vehicle, as is the case with pure ZEVs.

Vehicles that meet all of these minimum or “baseline” requirements earn a 0.2 PZEV allowance. Since ARB regulations do not specify particular fuel or propulsion technologies, there is a wide variety of potential vehicle fuel and drive system combinations that may qualify for PZEV allowance in the coming years. The overall ZEV allowance assigned to a vehicle is the sum of 3 individual assessments:

• Baseline (minimum) PZEV allowance	0.2
• Zero emission vehicle miles traveled (VMT) allowance or Advanced Componentry	0.0 to 0.6
• Low fuel cycle emissions allowance	0.0 to 0.2

Table 4-1 on the next page lists a number of existing and hypothetical vehicle types, along with estimates of the maximum potential ZEV allowance they might be eligible to earn:

Table 4-1
Draft Examples of Partial ZEV Allowance Vehicles, Full ZEV Allowance Vehicles, and ZEVs

Vehicle Type (Must meet all PZEV requirements)	Primary Energy Source	Secondary Energy Source	Zero Emission Range (miles)	PZEV Baseline Allowance	Zero-Emission VMT Allowance	Low Fuel Cycle Emissions Allowance	Total ZEV Allowance
Gasoline ICE	Gasoline	N/A	0	.2	0	0	.2
Gasoline ICE / HEV	Gasoline	Electricity	0	.2	.1 (components)	0	.3
CNG ICE	CNG	N/A	0	.2	0	.2	.4
LFCE ICE HEV, 0 mile ZE range	CNG, methanol, hydrogen	Electricity	0	.2	.1 (components)	.2	.5
Gasoline ICE HEV, 20 mile ZE range	Grid Electricity	Gasoline	20	.2	.3 +.1 (max off-vehicle charging)	.1	.7
Hydrogen ICE	Hydrogen	N/A	0	.2	.3 (0 NMOG)	.2	.7
Methanol Reformer FCV	Methanol	Electricity	0	.2	.3 (0 NOx)	.2	.7
Gasoline ICE HEV, 40 mile ZE range	Grid Electricity	Gasoline	40	.2	.4 + .1 (max off-vehicle charging)	.16	.8
LFCE ICE HEV, 20 mile ZE range	Grid Electricity	CNG, Methanol, etc.	20	.2	.3+.1 (max off-vehicle charging)	.2	.8
LFCE ICE HEV, 40 mile ZE range	Grid Electricity	CNG, Methanol, etc.	40	.2	.4 + .1 (max off-vehicle charging)	.2	.9
LFCE ICE HEV, 73 mile ZE range	Grid Electricity	CNG, Methanol, etc.	73	.2	.5+.1 (max off-vehicle charging)	.2	1.0
Gasoline HEV, 100 mile ZE range	Grid Electricity	Gasoline	100	.2	.6	.2	1.0
Hydrogen ICE HEV, 20 mile ZE range	Grid Electricity or H2 with FC APU	Hydrogen	20	.2	.3 +.3 (0 NMOG)	.2	1.0
Direct Methanol FCV	Methanol	Electricity	Any				ZEV
Battery EV	Grid Electricity		Any				ZEV
Stored Hydrogen FCV	Hydrogen		Any				ZEV

Abbreviations used in the table are:

CNG:	Compressed natural gas
FCV :	Fuel cell vehicle
HEV:	Hybrid electric vehicle
ICE:	Internal combustion engine
LFCE:	Low fuel cycle emissions
PZEV	Partial Zero Emission Vehicle
SULEV	Super Ultra Low Emission Vehicle
VMT:	Vehicle miles traveled
ZE Range:	Zero-emission range

It should be emphasized that the LEV II regulations do not establish specific ZEV allowances to be earned with particular fuel or propulsion technology choices. Rather, allowances are earned according to the three factors noted above, and depend on the actual performance achieved by a vehicle with a particular fuel and propulsion technology. The examples in the table below indicate staff's current assessment of the maximum achievable allowances possible for the vehicle types shown.

4.3.2 PZEV Availability

The following section outlines current information regarding the availability of production PZEVs, today and in the future (2003 and beyond).

4.3.2.1 MY 2000 PZEVs Presently Available

At the present time, only the Nissan Sentra 'CA' ("Clean Air") has achieved California certification for PZEV credit. Staff does not anticipate any further applications for PZEV certification for MY 2000 vehicles.

Nissan Sentra CA (Gasoline SULEV, PZEV Credit =.2)

Make	Model	Emissions Class	City/ Hwy EPA MPG	Primary Energy	Secondary Energy	Primary Propulsion	Secondary Propulsion
Nissan	CA	PZEV-.2 (SULEV)	26/ 33	Gasoline	N/A	Gasoline ICE	N/A

The 2000 model year Nissan Sentra CA is the first vehicle to be ARB-certified to meet SULEV requirements as well as the additional warranty and evaporative emissions controls necessary to achieve a baseline PZEV rating. Several key technologies allow the Sentra CA to achieve PZEV performance levels. These include:

- Double-wall exhaust manifolds,
- Quicker warm-up catalyst
- A new combustion control sensor, and

- An electronically controlled swirl control valve that reduces hydrocarbon emissions in both cold and warm start situations.

In addition, the radiators of all Sentra CAs are coated with Engelhard Corp.'s PremAir® coating, which converts ozone passing the radiator into oxygen.

The Sentra CA will be a limited production vehicle. Sales of the Sentra CA began in April 2000 in California.

4.3.2.2 MY 2000 SULEVs Not Qualifying For PZEV Credit

In addition to the Nissan Sentra CA, two other MY 2000 vehicles have met certification requirements for the SULEV standard. These vehicles will not earn PZEV allowances, however, because they do not yet meet all of the minimum baseline requirements necessary for PZEV status.

The MY 2000 Honda Accord SE has been certified to SULEV emissions standards, but has not been certified to attain PZEV allowance requirements for durability, warranty, or zero evaporative emissions at this time. The Accord SE would be eligible for a 0.2 ZEV allowance if the additional PZEV requirements were to be met.

The MY 2000 Honda Civic GX is a CNG fueled ICE vehicle that is ARB certified as a SULEV and already meets zero evaporation requirements. It does not yet offer the enhanced 150,000-mile emissions warranty required for PZEV baseline certification. Honda states that they do not yet have sufficient durability data on this vehicle to justify the warranty extension necessary for PZEV certification. Since CNG fueled SULEVs that qualify for a PZEV baseline allowance of 0.2 would also be eligible to receive 0.2 allowance for low fuel cycle emissions, the Civic GX could someday qualify for a 0.4 PZEV allowance.

Make	Model	Emissions Class	City/ Hwy EPA MPG	Primary Energy	Secondary Energy	Primary Propulsion	Secondary Propulsion
Honda	Accord SE	SULEV	23/20	Gasoline	N/A	Gasoline ICE	N/A
Honda	Civic GX	SULEV	28/34 (equivalent)	CNG	N/A	CNG ICE	N/A

4.3.2.3 Other Production Vehicles With Some PZEV Characteristics

The Toyota Prius is the first modern-day HEV to be offered for sale. As of January 2000, Toyota has delivered more than 30,000 units to customers in Japan. Toyota has announced its intent to certify the MY 2000 Prius HEV to SULEV standards, but is not expected to apply for certification to PZEV levels. Although the current Prius HEV is capable of traveling very short distances in ZEV mode, it cannot yet attain the minimum 20-mile all electric range necessary to earn a zero-emission range allowance.

If future versions of the Prius or similar gasoline HEVs with negligible zero emissions range meet PZEV zero evaporative emission requirements, they would attain an overall PZEV allowance of 0.2 baseline plus 0.1 for advanced electric drivetrain componentry, for a total PZEV allowance of 0.3.

The Honda Insight is the first modern-day HEV to be offered to customers in California. It is currently certified at ULEV emissions level, so it cannot yet qualify for a PZEV baseline allowance. The Insight HEV design emphasis is on high efficiency, and hybridization enables it to achieve the highest mileage and consequently the lowest CO_2 emissions of any gasoline-powered passenger car available in the United States.

The Toyota Prius platform, if modified to have a larger battery, a larger electric motor, and a charging port, could serve as the basis for a vehicle with significant zero-emissions range. Because the present design of the Honda Insight powerplant links the electric motor directly to the engine, it is not capable of any motor-only, zero-emission operation.

Ford has recently announced that it will be offering a 2003 MY hybrid version of its new SUV, the Escape. This hybrid SUV is expected to achieve nearly 40 mpg (city) and will also be certified to the SULEV emission standard. The hybrid Escape is expected to provide acceleration similar to the V6 Escape, while achieving better fuel economy than the 2 liter 4 cylinder Escape (23/28 mpg city/hwy). Ford is also pursuing the development of a zero evaporative emissions system for the Escape. An Escape that met PZEV requirements would qualify for a 0.3 PZEV allowance.

Make	Model	Emissions Class	City/ Hwy EPA MPG	Primary Energy	Secondary Energy	Primary Propulsion	Secondary Propulsion
Toyota	(Prius) U.S. Model name TBD	SULEV (target)	(TBD)	Gasoline	Electricity: 1.8 kWh total energy, ~.18 kWh useful energy	Gasoline ICE, (~43 kW)	Electric Motor, (~30 kW)
Honda	Insight	ULEV	61/70	Gasoline	Electric ~.9 kWh total, ~.09 kWh useful	Gasoline ICE (54 kW)	Electric (10 kW)

4.3.2.4 Other Power-Assist HEVs

Staff expects several additional "power-assist" parallel HEVs to become available before 2004. These HEVs are also expected to be equipped with relatively small motors with less than 25 percent of engine power capability, and very small battery packs (less than 2 kWh). Although these power-assist HEVs are designed primarily to improve fuel economy and do not necessarily reduce criteria emissions, they can significantly reduce CO_2 emissions. Sales of "power assist" HEVs would also require manufacturers to increase their design and production capability for motors, inverters, and battery packs, which may be used in other types of electric-propulsion vehicles.

4.3.2.5 PZEV Availability in MY 2003 and Beyond

Under the ZEV regulation, intermediate manufacturers may meet their entire ZEV obligation using PZEVs, and large manufacturers may meet 60 percent of their ZEV obligation. Other than the Nissan Sentra CA, discussed above, no manufacturer has announced definitive plans to market PZEVs in MY 2003. Manufacturers have indicated that the most difficult challenges to be met for PZEV certification are the zero evaporative emission level and the 150,000-mile emissions warranty. In addition, the timing of PZEV introduction likely will be affected by manufacturer-specific external cycles such as the planned retirement date for engine families and their replacement by new engines. Staff anticipates, however, that additional PZEV models will be announced prior to 2003.

4.3.3 All Electric Range and Efficiency Improvement

Both battery EVs and hybrid electric vehicles with zero-emission range that are able to charge from the electric grid can achieve high efficiency along with extremely low emissions. Typical battery EVs achieving 250-500 Whr/mile (AC) are also demonstrating an efficiency equivalency of 77-154 MPG (assuming energy content of gasoline is 38.6 kWh/gal). This high energy efficiency results in correspondingly low CO_2 emissions. Although vehicle operating efficiency and CO_2 emissions are not regulated by the ARB, staff recognizes that inefficient vehicles require more costly and complex systems to control criteria emissions. In addition, a malfunctioning low-efficiency gasoline vehicle operating up to 2 years between smog inspections has the potential to emit many times more emissions than a faulty high-efficiency vehicle.

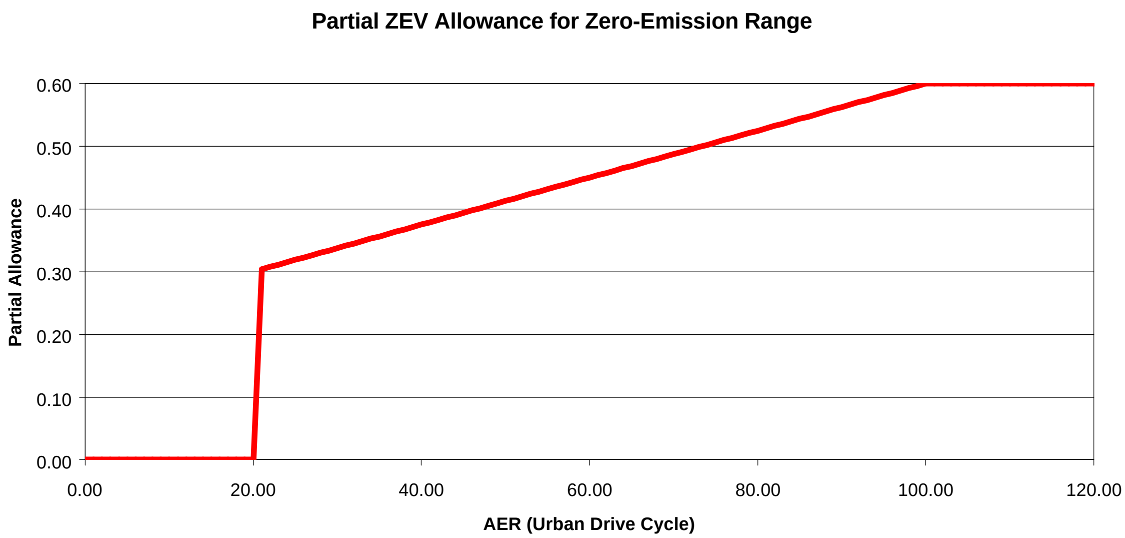
4.3.4 Partnership for a New Generation of Vehicles

The Partnership for a New Generation of Vehicles (PNGV) is a collaboration between the United States Government and the large domestic automakers. The long–term goal of the PNGV is to develop vehicles that will deliver up to three times today's fuel efficiency (80 miles per gallon) and cost no more to own and operate than today's comparable vehicles. At the same time, this new generation of vehicles should maintain the size, utility and performance standards of today's vehicles.

The PNGV program near-term development emphasis has been on diesel-powered vehicles, because its goals are narrowly focused on fuel efficiency. The Partnership has, however, also funded developments that may have significant impact on future emissions reductions. Program contractors have developed improvements in lightweight materials, high-power batteries, fuel cell components, and reductions in vehicle road-load. For example, a recent PNGV-funded prototype announcement for the GM Precept discloses an extremely low aerodynamic drag coefficient of .163, which is less than one-half of the drag exhibited by a typical modern car. The ability of auto manufacturers to reduce aerodynamic drag to these extraordinarily low values will substantially reduce the power and energy storage requirements of future ZEVs and PZEVs, and may accelerate the introduction of cost-effective near-zero or zero emission vehicles.

4.3.4 HEVs With Significant Zero Emission Range

Three PZEV allowances are added together to determine a vehicle's overall allowance. One of these three, the zero-emission VMT allowance, is based on the potential for realizing zero-emission vehicle miles traveled, and is determined as shown in the graph below.



During the development of LEV II, ARB staff believed that manufacturers would develop HEVs with battery packs that were smaller and less expensive than those needed for battery EVs, but still big enough to provide significant ZEV range and to justify recharging from the electric grid. These smaller packs for HEVs might have an energy storage capacity as low as 10-15 kWh instead of 30+ kWh in battery EVs, but would be sufficient to enable vehicles to attain a relatively large zero emission VMT allowance. Based on public announcements to date, however, staff does not believe that grid-charged hybrid electric capability will be made available on any MY 2000-2003 vehicles. The only hybrid electric vehicles expected during this time will probably be equipped with very small battery packs of less than 2 kWh capacity that are charged from gasoline-derived energy only. While LEV II was written to encourage vehicles with zero-emissions range like grid-connected HEVs because of their low emissions, high efficiency, and other ZEV-like attributes, it is unlikely that manufacturers will make use of this option to achieve higher PZEV allowances for zero-emission range before 2004.

Automotive manufacturers and researchers have, however, developed and demonstrated several prototype HEVs that demonstrate significant zero-emission range and are able to charge their battery packs with grid-supplied electricity. No manufacturer has announced when these types of HEVs will become available, and most cite the same primary obstacle claimed for the slow introduction of battery EVs--high battery cost. Although many of these advanced prototypes would not yet meet ARB's SULEV requirements, with further engine refinement to SULEV standards they would achieve very high PZEV credits because of their ZEV range capability.

Examples of functional prototype and demonstration "grid connected" hybrid vehicles include:

- Several GM EV-1 based show cars,
- GM Triax,
- DOE/ SAE Futurecar and Futuretruck Student-competition HEVs,
- Suzuki EV Sport,
- Volvo HEV,
- Ovonic-Modified (grid connected) Toyota Prius,
- Audi Duo.

4.4 On-Road Neighborhood and City Electric Vehicles

Several classes of small on-road electric vehicles have begun to emerge in the last few years that will displace gasoline vehicle usage and increase overall zero-emission miles traveled within California. These vehicles are under consideration because they offer a number of desirable characteristics:

- Very high efficiency
- Affordable to build, and affordable to purchase
- Neighborhood electric vehicle (NEV) performance is adequate with existing, affordable, lead acid batteries
- City Electric Vehicle (CEV) battery pack energy storage requirements are only about 1/3 that of a full sized EV, so the latest battery technology can be more affordable.
- Reduced congestion (possible to park two NEVs in a single parking space)
- Many niche market applications (station cars, resorts, theme parks, national parks, campuses, planned communities).

4.4.1 Background--Emerging Small EV Classes

Small EVs exhibit a wide range of capabilities and performance levels. They may be broadly classified as shown on the next page. Similar characteristics for full-range EVs are shown for comparison purposes.

Under current state law and ARB regulation, NEV/LSVs and City EVs all qualify as “passenger cars” and therefore are eligible to earn full ZEV allowances. In terms of trip replacement and the resulting air quality impact, however, it is clear that a NEV, City EV, and a full-range EV differ significantly. ARB staff plan to evaluate the relative emission benefits of the various new categories of vehicles.

Vehicle Type	DOT Class	Curb Weight	Energy Storage Capacity	Drive System Peak Power	Maximum Speed	Typical Range	Examples
e-bikes, scooters, motorcycles, etc. (1)	N/A	Varies	0.3- 2.8 kWh	~1kW- ~10 kW	Varies	less than 20 miles	ZAP, ebike, etc.
NEV/ LSV	LSV (Low Speed Vehicle)	950-1400 lbs.	4-9 kWh	~5-15 kW	Less than 25 mph (limited by LSV rqmnts.)	20-30 miles	GEM, Th!nk Neighbor, Bombardier NV, etc.
City EV (CEV)	PC	1800-2500 lbs. typ.	10-15 kWh	~20-30 kW	Typ. less than 62 mph	Typ. 40-80 miles	Toyota e-Com, Nissan HyperMini, Th!nk City, etc
3-Wheeled Enclosed Motorcycle (1)		Varies	3-10 kWh	Varies	28-60 mph	20+ miles	Sparrow
Full-range EV	PC	3200+ lbs.	15-35+ kWh	50-150 kW	70-80 mph	40-140 miles	EV1, EV-Plus, RAV4 EV, Altra, etc.

(1) Not eligible for ZEV credit

4.4.2 City EVs (CEVs)

This emerging class of vehicles is much smaller than most American vehicles and exhibits lower performance than the ICE vehicles currently available on the American market, but they are much more car-like than NEVs. Although the current prototypes listed below are not yet safety certified, production City EVs sold in the United States will be required to meet all existing federal DOT/Federal Motor Vehicle Safety Standards (FMVSS) requirements for equipment and crash protection. All are equipped with dual air bags, and many offer anti-lock braking systems.

Examples of near-term CEVs include:

Make	Model		Passengers	Curb Weight	Maximum Speed	Range/ Power	Battery Type
Toyota	e-Com		2	1742 lbs.	62 mph	60 miles 19 kW	Panasonic NiMH 288 volts x 28 ahr
Th!nk	City (MY 00)		2	2046 lbs.	54 mph	50 mi 27 kW	Saft NiCad 114 X volts 100 ahr
Th!nk	City (MY 01+)		2	TBD	TBD	TBD	TBD
Nissan	Hyper-mini		2	1852 lbs.	62 mph	60 miles 24 kW	Shin Kobe LiIon
Honda	City-Pal		2	2310 lbs.	68 mph	80 miles	NiMH 288 volts 28 ahr

Auto manufacturers are planning to sell large quantities of CEVs elsewhere in the world, especially in countries where fuel prices are relatively high or gasoline infrastructure is scarce. Most City EVs fit within the Japanese “microcar” classification limits, which restrict vehicle size to a length of less than 3400 mm (11 feet 2 inches) and a width of less than 1480 mm (4 feet 10 inches). In Japan, there is growing interest in this “microcar” class of for use as second vehicles. Some City EVs whose lengths are less than 2500 mm (8 feet 2 inches) are capable of parking 2-to-a-parking space to help avoid urban congestion. In countries where fuel costs are high, CEVs will be able to provide lower cost of ownership even in the relatively low build quantities expected in the early years of production. They are equipped with battery packs that are approximately one third the capacity (and cost) of those found in full-size, full-performance EVs. City EVs are also expected to demonstrate better operating efficiency than larger EVs and NEVs. All CEVs currently proposed are planning to make use of advanced battery technology (NiMH or LiIon).

Toyota is providing a fleet of 13 left-hand drive e-Coms for a demonstration program in Irvine, California. This program will be run by UC Irvine’s National Fuel Cell Research Center in cooperation with Toyota. The e-Com can charge at either 120 VAC Level I or Level II Inductive charging stations.

The Th!nk City is currently available for lease in Scandinavia. Plans are for 700 units to be imported into the US in 2000, with more than 300 of them coming to California for demonstration programs. Safety features include a driver-side airbag and seat belts with pre-tensioners.

Nissan’s Hypermini is the only NEV or City EV that is presently equipped with Lithium Ion batteries. Safety features include both dual airbags and anti-lock brakes. A Nissan Hypermini station car demo program in Yokohama is scheduled to begin in January 2000, with others to follow. Thirty vehicles are allocated for demonstration in California beginning this year.

4.4.3 Neighborhood Electric Vehicles/ Low Speed Vehicles (NEV/LSVs)

These small EVs have a curb weight of under 1800 lbs., are equipped with speed limiting devices that limit maximum speed to 25 mph, and are restricted to use on roads with posted speed limits of under 35 mph. This vehicle class was legalized on a community basis in California with the passage of Assembly Bill 110 in 1999. Arizona was the first state to legalize LSVs on a statewide basis. More recently, the National Highway Traffic Safety Administration (NHTSA) defined a new Federal Low-Speed Vehicle class to establish minimum safety and equipment standards for these vehicles (49 CFR Parts 531.3 and 571.500). These regulations define a LSV as “a 4-wheeled vehicle, other than a truck, whose speed attainable in 1.6 km (1 mile) is more than 32 kph (20 mph) and not more than 40 kph (25 mph) on a paved level surface”. Federal requirements do not require LSVs to make use of electric propulsion. The California vehicle code was modified under Senate Bill 186 to accommodate this new federal classification, and these vehicles have been legal for use on public roads statewide since January 2000. An important distinction between Federal and California law is California’s additional restriction of unladen weight to 1,800 lbs. or less.

Although these vehicles appear to be similar to golf carts, they offer substantially more performance, better safety features, and are much more road worthy. NEV/LSVs are generally capable of much better acceleration than golf carts and can achieve 25 mph quite rapidly. Golf cart performance is restricted in accordance to cooperative industry standards to 13-15 mph, due to safety and turf maintenance concerns on golf courses. NEV/LSVs are usually equipped with higher-pressure road tires that might damage turf if used on a golf course, and NEVs must also be equipped with much better brakes than would be needed on a golf course. At the present time, all NEV/LSVs on the market are purpose-built designs intended for use as NEVs and are not derivatives of existing golf-cart designs. These improvements also increase the price of a NEV/LSV to more than $3,000, which is more than a typical electric golf cart.

At the present time, NEV/LSVs do not display efficiency labeling, as is required of all other road vehicles. Present EPA test procedures specify that the test vehicles must operate at speeds that are above the capability of LSVs, so the existing test procedure cannot be used to measure the fuel economy or range of these vehicles. Although test information is not yet available for these vehicles, it is believed that their operating efficiency may not be nearly as high as that of City EVs, which are equipped with much more technologically sophisticated componentry. In many cases, it is possible that NEV/LSV operating efficiency may even be poorer than that of full-size and full-range battery EVs.

Examples of near-term NEVs and LSVs are as follows:

Make	Model	Passengers	Curb Weight	Range/ Power	Battery Type
Th!nk	Neighbor	2	950 lbs.	25 mile/ 5 kW	TBD
Th!nk	Neighbor	4	1200 lbs.	25 mile/ 5 kW	TBD
Bombardier	NV	2		30 mile/ 3.7 kW	Sealed lead-acid 72 volt system
GEM	E 825	2+ short bed pickup	980	25-30 miles/ 2.6 kW	Flooded Lead-Acid 72 volt system
GEM	E 825	2+ long bed pickup	1200	25-30 miles/ 2.6 kW	Flooded Lead-Acid 72 volt system
GEM	E 825-2	2	980	25-30 miles/ 2.6 kW	Flooded Lead-Acid 72 volt system
GEM	E 825-4	4	1280	25-30 miles/ 2.6 kW	Flooded Lead-Acid 72 volt system

Deliveries of the Th!nk Neighbor are scheduled to commence in November, 2000. It will be available for sale at selected Ford dealers, via the internet, and at other unspecified outlets, and base price is expected to be approximately $6,000.

Bombardier was the first NEV to apply for ARB certification. The Bombardier vehicles make use of sealed, maintenance-free lead acid batteries, and are available at a base price of $6,199.

GEM has received certification for its MY 1999 vehicles. Prices vary with model, and range from $7,000 to $10,000. Unlike some other LSV models, the GEM charging circuitry is designed to be compatible with existing, 120 VAC commercial GFCI-equipped outlets.

GEM NEV/LSVs are the only ones equipped with flooded lead-acid batteries (all others are sealed designs), and will therefore require battery maintenance. GEM recommends checking/ adding battery water to each cell at least once a month.

As noted above, under current state law and ARB regulation, NEV/LSVs qualify as “passenger cars” and therefore are eligible to earn full ZEV allowances. Due to their limited range and functionality, it is apparent that such vehicles will replace far fewer vehicle miles traveled, or trips, than City EVs or full range EVs. Staff thus has significant concerns regarding how such vehicles should be treated for ZEV credit purposes. ARB staff plan to evaluate the use and resulting emission benefits of such vehicles as information becomes available.

5 BATTERY TECHNOLOGY ASSESSMENT

5.1 The Battery Panel

The cost of batteries, both today and when produced in volume, is one of the most critical parameters of this review. To obtain the best available assessment, the ARB has contracted with a team of outside experts. This panel has met with leading battery suppliers and auto manufacturers. Their task is to review the state of the art regarding advanced battery design and manufacturing techniques, and report back to staff regarding likely cost trends for 2003 and beyond. Their draft final report will be presented at the May workshop.

5.2 Range vs. Cost

The current structure of the ARB regulatory and incentive scheme for ZEVs and partial ZEVs is intended to encourage the development of advanced batteries that will allow battery EVs to achieve extended range. For example, additional credit is given in the near term for ZEVs with a range of greater than 100 miles.

This approach has been taken in order to encourage the development of vehicles with sufficient range to cover the majority of trips taken by typical drivers. Such range has been thought to be necessary to achieve mass-market penetration. In addition, the use of advanced batteries has the potential to extend the life of the battery pack compared to conventional lead acid batteries, and thereby reduce the need to replace battery packs during the vehicle life. It has long been assumed that technical advances will reduce the cost of advanced batteries such that in addition to providing extended range, they will be more cost effective than conventional batteries on a lifecycle cost basis.

Some parties have argued that the ARB preference for advanced batteries should be revisited. Proponents of this view make the case that the most cost-effective application for battery EVs could be vehicles powered by lead acid batteries, and they question whether the increased range afforded by advanced batteries justifies the extra cost. Others have argued that one appropriate niche for battery EVs could be smaller, shorter-range vehicles for urban and commuter use, and that the ARB incentive structure should not discourage such applications.

Two threads of public comment that relate to this issue were presented at the March workshop. First, many EV drivers of lead acid vehicles testified that their existing vehicles provide more than adequate range for their daily driving needs. (This point is discussed in more detail in the EV Market, section 7 of this report.) They see no advantage to batteries that provide additional range at an increased cost, and would not take advantage of such an opportunity.

Second, one speaker presented an analysis of the "cost of increased range". In this analysis, the cost of an advanced lead acid vehicle was compared to that of a nickel metal hydride vehicle with greater range. ARB staff plans to repeat this analysis using our own methodology and assumptions, after our cost estimation methodology and the results of the Battery Technical Advisory Panel have received public review and comment.

This speaker concluded by recommending that the ARB eliminate the 100-mile minimum electric range threshold for granting multiple ZEV credits. This would allow shorter-range vehicles to qualify for multiple credits, and in the view of the speaker would increase the options available to ZEV manufacturers and purchasers. One possible outcome of this scenario would be a shift towards shorter-range, less expensive lead acid vehicles.

One other effect of such a change would be that larger NiMH vehicles (GM S-10, Ford Ranger, and DaimlerChrysler EPIC), which under the current regulation only get a 1.0 credit because their electric range is less than 100 miles, would get multiple credits. Specifically, if the ZEV multiple credit line were to be linearly extended below 100 miles, in 2003 the S-10 and the EPIC would get 1.787 credits, while the Ranger would get 1.227 credits. Thus, without a shift to lower-range lead acid vehicles, fewer vehicles would be necessary to comply with the 2003 requirement.

6 INFRASTRUCTURE ASSESSMENT

6.1 Introduction

To achieve zero and near-zero (SULEV) emission levels, together with minimal upstream refueling emissions, the advanced technology vehicles being developed by manufacturers often require the use of fuels other than conventional gasoline. Therefore it will be critical to ensure that the necessary refueling infrastructure is in place to support their widespread introduction.

Recently, the South Coast Air Quality Management District and CALSTART announced an Internet web sit that allows drivers of alternative fuel vehicles to locate refueling stations quickly and easily throughout California. The site covers electric, compressed and liquefied natural gas, propane and methanol fueling facilities. The site will also list ethanol and hydrogen fueling facilities when they become publicly available in California. Clean Car Maps is located at http://www.cleancarmaps.com. Users pick an alternative fuel and enter an address and they will receive a map with icons designating the locations of refueling sites in the area. Users can then click on the site name to get comprehensive refueling information from a web database.

6.2 Battery EVs

Public infrastructure enhances the utility of battery electric vehicles. Drivers can extend the length of their trips if they know that convenient recharging facilities will be available at their destination.

The public infrastructure for electric vehicle charging continues to expand in California. Currently, inductive electric charging stations and conductive electric charging stations are available at about 300 and 200 public locations, respectively. The bulk of the locations are in the greater Los Angeles/South Coast area, the San Francisco Bay area, the Sacramento Metropolitan area, and San Diego. In recent years, public infrastructure has expanded to locations in the North Coast, Central Coast, Sacramento Valley and San Joaquin Valley.

The charging facilities at individual locations vary. A grocery location may be equipped with a single electric charging station. A public parking garage is more likely to provide both inductive and conductive charging stations. Major destinations will have a larger number of charging stations. For example, parking Lot 1 at Los Angles International Airport is equipped with ten inductive electric chargers and 6 conductive chargers; there are also plans to place up to 20 inductive and 10 conductive electric charging stations at an additional airport parking lot (Lot 6) that is currently under construction.

ARB staff will continue participating in efforts to expand public infrastructure for electric vehicles. ARB staff has also identified several areas that warrant review in the near term:

- Centralization and maintenance of up-to-date information on public charging station locations and operational status, with dissemination of the information via Internet and annual publication (currently being provided by CalStart and Clean Car Maps).
- Review and revision, if appropriate, of the criteria for selecting public charging locations to take into account recent increases in electric vehicle range.
- Modification of the public infrastructure to accommodate upgrades to chargers and connectors, and additional electric charging technologies.
- Development of state regulations and local ordinances to discourage parking of internal combustion engine vehicles ("ICEing") at electric vehicle charging stations.
- Promotion of a courtesy charging protocol to allow more than one user access to a single electric charging station.

6.3 Grid-Connected Hybrid Vehicles

Grid-connected HEVs are generally expected to make use of the same public and private electric charging infrastructure that is currently being installed for battery EVs. One possible difference between battery EVs and PZEV HEVs would be a potential reduction in the demand for higher-power (Level II) charging stations, due to the fact that such HEVs can run on APU power when their battery packs are depleted. It may even be possible for 20 to 40 mile zero-emission range HEVs to make significant use of Level 1 charging (standard 120 VAC), because the smaller battery packs in these HEVs will be able to accumulate useful charge in reasonable time periods with more commonly available Level 1 outlets.

6.4 Fuel Cell Vehicles

In addition to testing vehicles, the California Fuel Cell Partnership (discussed in section 4.2.2.2 above) will also identify fuel infrastructure issues and prepare the California market for this new technology. Initial demonstration vehicles will run on hydrogen, directly from tanks on board the vehicles. Subsequent demonstration vehicles are likely to run on methanol fuel. Technology for other liquid fuels such as a cleaner form of gasoline will be evaluated. A key goal of the Partnership is to determine the best fuel infrastructure for the market entry of fuel cell vehicles.

The Partnership will be devoting considerable attention to fuel cell fuel infrastructure issues. Staff will monitor the Partnership's efforts in this regard and report on status as appropriate.

6.5 Compressed Natural Gas (CNG) Vehicles

There are currently more than 228 CNG vehicle refilling stations in California, of which 104 are available to the public. Most of these are “fast fill” type stations that are capable of refilling CNG vehicles in as little as 2 to 4 minutes.

Although the “fast fill” fuel dispensing infrastructure is relatively sparse, low pressure natural gas is already delivered to most residences in California. Thus manufacturers are working to develop “time fill” devices that would be suitable for home refueling use. These “time fill” devices may take 6-8 hours (overnight) to fill a vehicle, but their availability could make dedicated CNG vehicles a much more viable option for non-fleet users.

7 THE EV MARKET

7.1 Introduction

One key issue, as we look to 2003, is the nature and extent of expected market demand for electric vehicles. Do markets exist that can absorb the number of vehicles that the regulation requires to be placed? Of all the issues associated with the zero emission vehicle regulation, this one appears to generate the greatest divergence of opinion and the most strongly held beliefs. In staff's view it is also the most difficult area in which to develop reliable estimates.

To sort through these complex issues, this chapter first discusses EV market demand as evidenced today. Next it outlines reasons why in staff's view the marketing experience under the MOA demonstration program is not necessarily definitive in determining what would occur under a more comprehensive 2003 program. It then describes the size of various market segments that can make use of EVs. Finally, it discusses key elements needed to mount a successful EV marketing effort in support of the 2003 regulation.

Clearly, more people know about electric vehicles today than did so three to five years ago. This increased awareness is the foundation of future market efforts. We recognize that considerable time and effort could be spent debating the strengths and weaknesses of the various past efforts. The central issue before the Board, however, is what is likely to occur under the very different circumstances of 2003. Thus our focus throughout the Biennial Review process is on looking forward rather than backward

7.2 EV Market Demand Today

This section summarizes information available today regarding demand for EVs, drawing upon testimony at the March workshop, staff's review of marketing strategies and efforts undertaken to date by manufacturers, and surveys of EV drivers.

7.2.1 Workshop Testimony

One clear message provided at the March workshop is that those who drive the vehicles are extremely happy with them. Drivers appreciate being able to drive without contributing to smog, fuel spillage, climate change, or other pollution problems. In addition to such societal benefits, drivers also mentioned many desirable attributes of the vehicles that are enjoyed in everyday commuting. Drivers spoke of the convenience of home charging, the smooth, quite acceleration, the low operating cost, and vehicle reliability. A fleet manager described the extensive real-world service that his fleet of EVs has provided in a variety of applications.

Many speakers at the workshop testified that although they are interested in leasing an EV, they have been unable to do so because vehicles are not currently available. For example, drivers who lost the use of an EV1 due to the General Motors recall, and who wish to replace the EV1 with another electric vehicle, have in most cases been unable to do so. A fleet manager for a major utility testified that he anticipated having difficulty meeting his desired lease level of about 200 EVs annually. ARB staff is also having difficulty obtaining EVs for the EV Sacramento and EV Loan programs, which place EVs with government agencies.

Drivers testified that their neighbors, friends and interested persons on the street do not know that production EVs are available to "regular people." These EV drivers expressed concern with the adequacy of manufacturer marketing efforts and government agency educational programs. Some EV drivers also stated they have more recently stopped encouraging potential customers to visit EV dealers, because test drive opportunities are difficult to arrange and the dealers are uncertain regarding when EVs would be available. Apparently some dealers are not maintaining or adding to waiting lists.

Several manufacturers, meanwhile, noted that from their standpoint the sale of EVs is very labor intensive and expensive relative to conventional vehicles. For example, sales staff need extensive training, additional time and effort is needed to educate customers regarding new technology, the ratio of sales to initial inquiries is relatively low, and time and effort are needed to deal with infrastructure installation issues. These manufacturers indicated that the time it took to place the MOA vehicles, the lease rate adjustments made for marketing purposes, and the incentive programs offered reflect a limited fleet niche EV market. They conclude that a general EV market does not exist that would be profitable for EV dealers. In general, manufacturers argued that there are fundamental challenges to placing EVs at the required levels, due to high cost, limited range, and the difficulties inherent in achieving widespread market penetration with a new technology.

7.2.2 Manufacturer Marketing Analyses, Strategies and Efforts

In letters dated September 28, 1999, and November 2, 1999, ARB staff requested information on auto manufacturers' marketing activities since the initial ZEV launch. All auto manufacturers responded to the request in a timely manner. ARB staff has reviewed the submitted materials. Much of the information submitted was designated as confidential by the manufacturers and has been handled as such by ARB staff. As a consequence, certain information could only be described in general terms and is included in the general overview. Individual manufacturer's marketing analyses, strategies and efforts described below are based on public presentations by the manufacturers and on published materials.

<u>Overview</u>

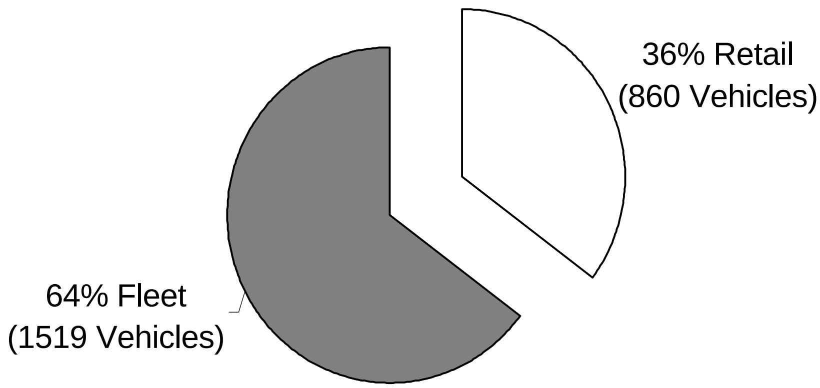
The manufacturers offered a variety of EV platforms to the marketplace. Only General Motors offered more than one platform. The majority of the manufacturers targeted fleet commercial customers to meet their MOA obligations. Two manufacturers, GM and Honda, had retail customers as their primary market targets. Table 7-1 below describes each manufacturer's market target groups and its EV platform. The majority offered their EVs through three years leases. The leases typically covered batteries, maintenance and road service; some leases included insurance and chargers. Only the lead acid battery version of the Chevrolet S10 Electric truck was offered for purchase.

Table7-1
Manufacturers' Market Targets and Vehicle Models

Manufacturer	**Primary Market Target and Vehicle Model**	
	Retail Customer	**Fleet/Commercial Customer**
Daimler-Chrysler		EPIC (5 seat minivan)
Ford		Ranger EV (2 seat truck)
General Motors	GM EV1 (2 seat car)	
		Chevrolet S10 Electric (2 seat truck)
Honda	EV Plus (4 seat car)	EV Plus (4 seat car)
Nissan		Altra (4 seat minivan)
Toyota		RAV4 (4 seat sports utility)

The majority of the manufacturers describe the introduction of their production EV models as demonstration programs, with goals that focus on advanced battery evaluation and on market and infrastructure issues important for future growth in the EV market. To retain control over the vehicles for evaluation purposes and to protect the customer from "demonstration" EV technology, manufacturers offered the EVs for lease only. Several manufacturers mentioned that support of charging infrastructure was a component of their marketing of the EVs. The majority identified the fleet market approach as the most reliable and effective means to assess the operational and durability aspects of EVs. Prime fleet customers were identified as those required to purchase alternative fuel vehicles under the Energy Policy Act (EPACT), including government agencies and electric utilities, and companies wanting to promote an environmentally conscious image. Some manufacturers mentioned that they wanted to avoid "higher risk" factors associated with retail marketing. According to information

Figure 7-1:
Placement of EVs in California



available to ARB staff and illustrated in Figure 7-1, about two-thirds of the EVs in California have been placed in fleets.

Several manufacturers reported EV marketing expenditures, on a per vehicle basis, of up to several orders of magnitude higher than expenditures for similar conventional (non-electric) vehicles. ARB staff and some manufacturers attribute the higher expenditures per vehicle to the limited number of EVs being produced and the cost of the additional educational aspects of marketing to promote a new technology. However, ARB staff also received information that indicates that marketing expenditures for a newly introduced conventional car model can be similar in magnitude in the first or second year of introduction.

Several manufacturers mentioned the need to set lease rates that did not recover production costs but instead would be competitive with other manufacturer offerings and that would ensure sufficient placements to meet MOA obligations. Several manufacturers mentioned that EVs are harder to place than conventional cars; additional effort was needed to educate the customer and additional time, typically 5 or 6 months, was needed to place an EV. Several manufacturers further stated that there is no market for EVs and that EV sales would not be profitable for dealers.

The next sections provide more detail regarding the activities of individual manufacturers.

DaimlerChrysler

DaimlerChrysler's demonstration program has used a single EV model, the 5 passenger EPIC minivan. EPIC is an acronym for Electric Power Interurban Commuter. The EPIC combines the Dodge Caravan/Plymouth Voyager minivan platform with advanced electric vehicle technology and off-board chargers that provide fast recharging capability. Using the fast charge, the EPIC is capable of more than 300 miles service in a single day.

Staff notes that the EPIC's charging system differs from the standard inductive and conductive systems used by all other vehicles. For a captive fleet with central recharging this is not a problem, and the fast charge capability provides significant benefits. For other applications that need to make use of public charging infrastructure, including retail public customers, the lack of a standard charging interface presents a impediment to more widespread use.

DaimlerChrysler chose the minivan platform for the EPIC because of the popularity of its minivans and because of the minivan's versatility to either carry passengers or to be used as a utility vehicle. The EPIC, with a combination passenger and cargo payload of 925 pounds, has initially been marketed for lease to fleet customers. DaimlerChrysler identified governmental entities, electric utilities and commercial fleets with short-range delivery requirements as primary targets with a particular interest in the U.S. Postal Service.

To meet its MOA commitment, DaimlerChrysler began to place MY 1999 NiMH battery-powered EPICs in the 1998 calendar year. To date, 185 EPICs have been placed in California. Major customers include the Xpress airport shuttle service at Los Angeles International Airport, US Postal Service offices in Harbor City and Huntington Beach, UCLA, military bases, municipalities, and business fleets. EPICs are also placed at dealers where they are used for demonstrations.

DaimlerChrysler has used a target-direct-mail campaign with small incentives (including radios and flashlights), advertisements in regional business journals, literature and the normal government and utility fleet bid process to market the EPIC. Fleet managers have been invited to selected dealers for a test ride and may have been visited by DaimlerChrysler's Alternative Fuel Vehicle Sales and Marketing representatives. The primary marketing theme has been "Meet the EPIC Electric Minivan - Batteries Included" with emphasis on the EPIC's practicality and zero emissions.

Ford

The Ranger EV truck is the single model used in the Ford demonstration program to date. Based on Ford's best-selling compact truck platform, the Ranger EV has a regular cab and payload capacity of 700 pounds if equipped with lead-acid batteries, or 1,250 pounds with NiMH batteries. Ford first introduced its lead-acid battery-powered version of the Ranger EV pickup truck in 1998. The NiMH version was made available in 1999.

Prior to introducing the Ranger EV, Ford conducted focus groups, marketing clinics and dealer meetings. Ford has targeted fleets for these vehicles because it perceives fleet customers as generally having shorter, more predictable driving patterns than retail customers. However, Ford has marketed the Ranger EV to both fleet and retail customers. Sales and service are through Ford dealers to provide customers with a "mainstream" or "conventional car" experience. To date, 356 Ranger EVs have been placed in California (of a total of 915 nationwide). The California customers are predominately government with some utility, private fleet, and retail customers. Ford appears to have retained about ten percent of these California Ranger EVs for demonstration purposes.

Ford reports that it has 15-20 Ranger EVs scheduled continuously at various events including government fleet events, dealer events, media events and auto shows. Other Ford marketing efforts include joint marketing with utilities, telemarketing, direct mailings, Ford websites, and on-going print ads. Ford's marketing message appears to focus on the Ranger EV having the "Best in Class" design features of a gasoline Ranger and proven advanced EV technology to guarantee it is "Built Ford Tough". According to Ford, its California marketing expenditures per Ranger EV in 1999 were 6.5 times that of a comparable gasoline Ranger.

In August 1999 Ford introduced additional incentives to encourage Ranger EV leasing. A reduced lease rate of $199 per month was put into effect for a Youth Awareness Program, and $7000 vouchers were made available to reduce the lease cost to public and private schools, parks, and zoos.

Ford has entered into an agreement with the United States Postal Service to provide 500 electric vehicle platforms, based on the Ford Ranger, for use as Postal Service vehicles. Most recently, Ford has announced plans to market the two passenger Th!nk City and Th!nk Neighbor vehicles in the United States—the first vehicles of that type to be offered by a major automobile manufacturer in this country. The Th!nk vehicles will be marketed to the general public. Ford has indicated that it believes a market exists in the United States for these urban commuter cars, and has recently undertaken a television advertising effort featuring the Th!nk City. Various demonstration programs featuring the Th!nk and other similar vehicles are being planned, and ARB will follow them with interest.

General Motors

General Motors offered two EV models in its demonstration program, the 2-passenger GM EV1 with a payload of 440 pounds and the Chevrolet S-10

Electric compact truck with a payload of 950 pounds. General Motors has marketed three versions of the EV1--the 1997 Generation I with lead acid batteries, and the 1999 Generation II with advanced lead acid or with NiMH batteries. The EV1 has been marketed for retail applications, with 768 placed in California. The Chevrolet S-10 Electric, offered with lead-acid or nickel-metal hydride batteries, has been marketed for commercial applications with 227 placed in California, out of more than 450 placed nationwide by the end of 1999. The target customers for the Chevrolet S-10 Electric include electric utilities, government agencies, colleges and universities, theme parks, zoos and airports.

In support of EV technology development and marketing, General Motors began consumer research in 1989. Their market research efforts have included a two and one-half year consumer test fleet drive program beginning in 1994 (the PrEView Drive), an early adopter marketing focus group, an EV1 owner survey, and recent market positioning research. Through customer input from the PrEView Drive, General Motors modified its EV product and determined the attributes of the early adopter target market.

General Motors gave the EV1 a unique General Motors (GM) badge and served retail customers through selected Saturn dealers and an EV specialist team. Currently, 33 Saturn retailers in Los Angeles, Orange County, San Diego, the San Francisco Bay area, Sacramento, Phoenix and Tucson lease and service the EV1.

Due to the recent recall, the MY 1997 Gen I EV1 vehicles are being stored by General Motors until the engineering and validation of a new replacement charge port is completed. Drivers who lost the use of Gen I vehicles are being given the option to transition to a Gen II EV1, or wait until rebuild Gen I EV1s are available. Staff’s understanding is that demand for Gen II EV1 vehicles exceeds the available supply. General Motors has not committed to additional production at this point.

General Motors marketing efforts have targeted regional market locales and used various media including television, radio, outdoor, newspaper, magazines, internet site, direct mail, and brochures. The marketing efforts include promotional activity at schools and events, an EV1 test drive road show, and owner club support. Marketing themes have included "Upgrade your drive. The electric car is here.", "You can't hear it coming. But it is.", and "Clean air goes in here. Clean air comes out here."

<u>Honda</u>

Honda originally intended to place roughly 75 percent of its 2-door, 4-passenger EV Plus vehicles with retail consumers through selected dealers. The target customers were "innovators" and "early adopters." Honda started with four dealers and markets and expanded later to four additional dealers and market areas. To date, about a third of the 276 vehicles placed in California have gone to retail consumers. According to Honda, the EV Plus retail customer profile was typically that of an "Enviro Leader" or a " Techno Champ." The "Enviro Leader' was described as having a concern for society and ecology, at the vanguard of environmentalism, politically active, and pragmatic, seeking a "mainstream EV." The "Techno Champ' was described as the affluent innovator, with a technology focus, driven to make an "EV statement", believing the EV PLUS is the "best EV made", and dedicated to the EV.

According to Honda, its demonstration program was intended to introduce the product to the retail market, create public awareness and interest in the EV PLUS, and get potential customers into the dealerships and encourage them to experience the EV Plus. To this end, Honda reports that it has encouraged media evaluation of the product, supported private and public events, placed ads in many magazines and newspapers, and made direct solicitations. Marketing themes included "A car with a cord. Sounds like Honda." and "Zero gallons to the mile." Additionally, Honda has made a study of EV rejectors (those who expressed interest but did not lease the vehicle) and has an ongoing study of EV customers for customer satisfaction.

In 1999, Honda completed its MOA commitment and finished placing the last of its Honda EV Plus vehicles. Although Honda does not plan to continue production of the EV Plus at this time, it maintains the capability to resume production. Honda currently is focusing its efforts on EV Plus customer satisfaction issues, which will continue at least until the end of the vehicle leases. In addition, at the conclusion of their initial three-year leases the Honda vehicles are being re-leased, with the original customers being offered the opportunity to re-lease the vehicles at a reduced monthly rate of $299.

Nissan

Nissan's demonstration program is using an all-new Altra EV 4-passenger 4-door minivan with a payload of 820 pounds. The Nissan Altra EV is the first production electric vehicle that is equipped with lithium-ion batteries. Nissan outfitted the first 30 demonstration Altra EVs with data loggers that record 31 different types of information on vehicle performance. Nissan also conducted various customer surveys and interviews to provide basic data for evaluation of vehicle performance, and user perception and experience.

Anticipated individual buyers were identified as wealthy homeowners with a fleet of two or more vehicles. The distance between home, work and the nearest Nissan retailer would be typically 30 miles or less. These customers were also expected to be highly educated couples living in suburbs or fringe towns of major metropolitan centers. Technically savvy early adopters, and those committed to environmentally friendly products were also expected to be early Altra EV buyers. Target fleet customers were expected to be both those required to purchase alternative fuel vehicles under the Energy Policy Act (EPACT) and also those companies wanting to promote an environmentally conscious image.

Initially, 30 demonstration vehicles were split evenly between the retail and fleet markets by the Los Angeles office of Nissan's American research subsidiary, Nissan Research & Development. The individual drivers are Nissan employees using the company vehicle lease program; other Altra EVs have been placed with utilities located in Northern and Southern California. A market-oriented program to place 98 demonstration Altra EVs is to be conducted by Nissan's American sales and marketing headquarters, Nissan North America. To date, 81 vehicles have been placed statewide.

The Altra EV vehicles were made available to demonstration customers directly from Nissan through a comprehensive lease program. A direct lease approach was selected for this program rather than a typical dealership distribution so information would flow directly between customers and the test engineers. To date, the majority of Nissan's marketing activities focus on fleet managers, through participation in key conferences and EV events. Nissan has additionally supported various public awareness/educational events. The marketing theme was "a friendly, high-tech electric vehicle for every day life."

After the initial California placement in 1998, Nissan decided to change to a different lithium-ion battery supplier. Due to efforts in making this change, Nissan did not produce any MY 1999 Altras. The new battery pack was incorporated in MY 2000 and was introduced in California in December 1999. Nissan plans to fulfill its MOA commitment by the end of calendar year 2001.

<u>Mazda</u>

To date, Mazda has purchased credits to meet its MOA obligations and therefore has not offered any ZEVs under the Mazda nameplate.

<u>Toyota</u>

The Toyota demonstration program uses a single EV model, the RAV4 EV. This EV is based on an existing platform, Toyota's 4-door, 5-passenger RAV4 sport utility vehicle. The RAV4 EV has a payload capacity of 827 pounds. Toyota considered several surveys of retail customers and placed prototypes with electric utilities before deciding to focus initial marketing efforts on major electric power utilities and fleet customers. Toyota has placed 486 RAV4 EVs in California to date (of 683 placed nationwide), primarily in electric utilities and government fleets. Toyota initially provided RAV4 EV servicing through contracted utilities and a municipality, and later expanded to offer service at a few select dealers.

To reach the fleet market, Toyota has concentrated RAV4 EV advertising efforts on print ads in various fleet publications, supporting product brochures, Internet website marketing ads, and direct active participation in alternative fuel vehicle promotional events such as EV expositions, auto shows, and "ride and drives". Some marketing themes that Toyota has used include "all the comforts of a RAV4 but none of the gas, oil, exhaust…", "the technology may be new, but the reliability is Toyota through and through" and " you may not be able to tell you're driving an electric vehicle. But the environment can."

In April 1999, Toyota announced that it had placed enough vehicles to satisfy its MOA commitment. Toyota is placing additional vehicles beyond the required MOA level, and will continue product development and the collection of in-use information about range, performance and market acceptability of the RAV4 EV.

7.2.3 Survey Results

The EV driver experience provides important information to manufacturers, regulators and future customers on the utility and viability of EVs in the "real world". Lessons learned with the EVs placed to satisfy MOA obligations can be used to better define the future EV marketplace by educating potential customers, identifying necessary technology improvements, and identifying desirable EV platforms. Various organizations, including the manufacturers, have surveyed the selected individuals or agencies that have received MOA EVs. The results of past surveys and surveys planned in the near term by groups other than the auto manufacturers are briefly described here.

At this time, ARB staff has only obtained results from one survey, conducted in 1998, that included a significant number of retail customers. While ARB staff is aware of plans to conduct a new major statewide survey of EV drivers, the results are not yet available. In the meantime, ARB staff obtained a preliminary description of the retail customers' "EV Driver Experience" by conducting an informal e-mail survey of EV drivers. Staff also received testimony at the March 29, 2000 workshop in Sacramento regarding several Internet-based surveys of EV drivers. Individuals were also invited to submit written testimonials regarding their EV driving experience to ARB staff. The submittals will be used by staff to produce a composite description of the "EV Driver Experience". The individual submittals also will be compiled and provided to the Board.

7.2.3.1 Retail Customers

Because retail customers were their primary market targets, there is extensive retail customer experience with the GM EV1 and the Honda EV Plus. The GM EV 1 was available for retail leases as early as December 1996. The Honda EV Plus has been available since 1998. The Ford Ranger is also available to retail customers. Surveys of retail customers include the following:

August 1998 Electric Vehicle Owner Survey

In mid-1998, the Mobile Source Air Pollution Reduction Review Committee (MSRC), in the South Coast Air Basin, distributed a survey to 284 EV Owners/Lessors who took advantage of the MSRC's buy-down incentive. 106 surveys were returned. All surveys returned were used in the comment portion of the survey, and 99 surveys were used in the quantitative analysis. The majority of the respondents were most likely retail customers, given that 77 percent of the EVs covered by the surveys received were for the two-seater GM EV1. The average length of ownership was slightly more than 13 months, and the average odometer reading was almost 9,000 miles.

The survey focused on characterizing the EV driver and EV use. 82 percent of the EV drivers were male. The EV was typically the primary car in a household with more than one vehicle. When asked why they purchased/leased their EV, the top three responses were: (1) concern for the environment or a desire to do their part to help clean the air, (2) a desire to be one of the first to adopt an up and coming technology, and (3) the EV's range fit their commute patterns/habits. Based on the survey, the EVs appeared to meet a wide variety of transportation needs:

- Commute to and from work or school (71 percent)
- Work/business purpose during the work day (63 percent)
- Shopping, errands during the week (88 percent)
- Family trips/outings, errands on the weekend (75 percent)

February 2000 Informal Survey Conducted by ARB Staff

There is currently minimal information from independent parties on the retail customer's EV driving experience. To provide information on their EV experience for this biennial review, ARB staff conducted an informal survey of EV drivers via two Internet e-mail groups for EV1 and Honda EV Plus drivers. At this time, staff has received about two dozen responses. A description of the survey results is included here.

To date, the majority of respondents are GM EV1 drivers, with a few who drive the Honda EV Plus or both vehicles. All of the respondents, regardless of how long they have driven the vehicle, rate their overall EV experience as very positive. Almost all of the respondents mention performance, quiet operation, minimal maintenance requirements, convenience of overnight home charging ("a full tank" each morning) and that the vehicles are "fun to drive" as contributing to their overall experience. Those driving EVs using advanced battery technologies, with EV range of 90 miles or greater, perceive a reduced need for public chargers except in strategic locations to allow occasional long distance trips. Respondents mentioned that they had initially expected that they would need to change their driving habits, but instead found that the EV meets about 95 percent of their transportation needs without any special adaptation. Some respondents remarked on an unmet market demand for 4-seat EV platforms, and their desire for lower vehicle lease/purchase costs.

Statewide Electric Vehicles Users Survey

A comprehensive statewide survey of EV users sponsored jointly by the California Electric Transportation Coalition, the California Energy Commission and the MSRC was sent out in March 2000 and a final assessment is expected shortly. When available, a summary of this survey's results will be provided in the staff report.

7.2.3.2 Fleet Customers

Fleet customers are those who drive commercial rental EVs or a workplace fleet EV. Fleet customers typically have access to several EV platforms, including 2 or 4 seat passenger cars, trucks, utility vehicles and vans. Surveys relevant to fleet customers include the following:

Air Resources Board Internal User Survey

The ARB Test Fleet, described further in Chapter 6.4.1, makes vehicles available to ARB employees for a period of two days up to a week. From July 1997 to August 1999, 245 employees made more than 2,800 trips with the test fleet. Two popular test fleet vehicles, a Honda EV Plus and a GM EV1, have been driven more than 25,000 miles and 20,000 miles, respectively. The employees were asked to complete a survey regarding their experience with each EV model. Analysis of 141 surveys returned by 99 employees indicates that the respondents typically had a positive to most positive overall experience driving the EVs. About 60 percent of the respondents indicated that they would consider leasing an EV for personal use. Some respondents identified several factors that they considered as impediments to leasing, including limited range, cost, and the inconvenience of charging. However, ARB staff note that the test fleet user does not typically have access to a charger at home and must share access to chargers at work.

Office of Fleet Administration Daily Rental Electric Vehicle Survey

The Department of General Services, Office of Fleet Administration operates several State garages that provide daily and long-term vehicle rentals to state agencies. Since July 1997, the State garage in Sacramento has offered free daily rental of the Honda EV Plus and the GM EV1. As of October 1999, more than 525 round trips, averaging 20 miles, have been made with a fleet of five EVs. The EV users were given the opportunity to complete a short survey on their EV driving experience. ARB staff analyzed 70 surveys turned in over a several month period in mid-1999. All of the respondents indicated that they were satisfied with the overall performance of the EV and that the driving range of the EV met their needs (for the rental). Almost 70 percent indicated that they would consider leasing or buying an EV. The most frequent comment received was that the EV was easy to drive and performed well. 10 of the 84 respondents also mentioned that the range was too limited for full-time use.

Southern California Edison's Municipal Fleet Survey

In 1999, Southern California Edison surveyed a total of 63 municipal agencies, colleges and transit agencies regarding their experience with their EV fleets. These fleets had a total of 178 EVs including the Chevrolet S10, Ford Ranger, GM EV1, Honda EV Plus, and Toyota RAV4. These agencies also had 67 vehicles in the acquisition process. These vehicles are typically used for administrative, enforcement and inspection purposes or as pool/loaner vehicles. On a per vehicle basis, 84 percent of those surveyed were satisfied with the operation of the EV. Areas of dissatisfaction included reliability, range and seat/payload capacity. While 96 percent of the agencies were interested in expanding their EV fleets, the respondents cited cost (33 percent) and performance/range (53 percent) as barriers to greater EV use.

Near-Term Plans to Survey Commercial EV Rental Drivers

ARB staff has worked with EV Rentals, in conjunction with Budget Rent-a-Car, to develop a survey to offer to short-term commercial EV renters at several California airports. ARB staff will describe the survey and responses, if available, in the next staff report.

7.3 Demonstration Market Experience Not Easily Applicable to 2003

To date, EV marketing has primarily taken place in the context of the MOAs between the automakers and the ARB. Under the MOAs, the automakers committed to participate in an advanced technology battery demonstration project. Each automaker agreed to produce their pro-rata share of approximately 1,800 advanced battery vehicles between 1998 and 2000.

ARB staff believes that the placement of the MOA vehicles differed from a normal “market” in several significant respects.

- The manufacturers developed target audiences and marketing approaches appropriate to the small number of vehicles in question, generally several hundred per manufacturer.
- By the same token, the vehicles chosen for development could be aimed at specialized market segments; none of the manufacturers chose to develop a five passenger four door sedan.
- Manufacturers used a variety of approaches to sell, distribute and service the vehicles, but no manufacturer marketed its vehicles at all dealerships.

- Due to the new technology employed, EVs imposed unusual information and training demands on all involved parties--customers, dealership staff, infrastructure providers, and marketing staff.
- Manufacturer pricing strategies were aimed at generating the required number of vehicle sales and were not set in a competitive fashion based on prices of otherwise equivalent conventional vehicles.
- Most vehicles were available for lease only rather than for purchase.

As the programs unfolded, it appears that real world start-up problems also intruded. Staff has received testimony and written submittals from individuals indicating that in their view they had to overcome unusual barriers in order to lease an EV. Examples included sales staff who are unfamiliar with the vehicles, long delays in getting information, ambiguous or contradictory information regarding “waiting lists” to obtain vehicles, and long delays in getting vehicles once orders have been placed. (Staff notes that one manufacturer testified that its sales throughput was intended to be "low and slow" to serve "intenders" and to sort them from the "curious unqualifieds.") A more general point was also made that it has been difficult for the public to get information regarding available electric vehicles and their characteristics.

Manufacturers have stated that it was difficult to place the relatively small number of MOA vehicles. They then conclude that based on their MOA experience it will be almost impossible to meet the 2003 requirement. Staff believes, however, that the results of the narrowly targeted, specialized, almost experimental MOA marketing efforts, with vehicles priced well above comparable conventional vehicles, do not necessarily indicate that a broad based approach with competitive pricing could not succeed. When Ford reduced its price on the EV Ranger, for example, the available vehicles were quickly placed.

On the other hand, some parties have argued that the manufacturer marketing and sales efforts were intentionally half-hearted and ineffective. Staff does not subscribe to this viewpoint either. Rather, staff concludes that the manufacturers made good-faith efforts to meet their MOA demonstration vehicle placement obligations. The manufacturer strategies and efforts have, after all, been successful in accomplishing their intended purpose. All MOA vehicles produced to date have been placed, and at present the number of interested customers exceeds the number of vehicles available. Manufacturers had no reason to attempt to create demand for a large number of vehicles when only a small number of vehicles were being produced. Nor could manufacturers be expected to voluntarily offer large numbers of additional vehicles given the high cost of producing each vehicle, and the losses sustained on each lease. Given that the manufacturers sustain a loss on each lease, they had an interest in limiting the number of vehicles placed.

In summary, the MOA marketing efforts provide an opportunity to begin to understand the factors involved in advertising, selling and supporting electric vehicles. Lessons have been learned which will be of value in future efforts. The MOA experience does not, however, lead to definitive conclusions about the prospects for 2003.

7.4 Potential 2003 Demand for EVs

To attempt to provide useful information regarding the possible market in 2003, staff has investigated several applications that lend themselves well to being served by electric vehicles. For this exercise we assume that the vehicles would be priced to be roughly competitive to comparable conventional vehicles on a lifecycle cost basis. We recognize that at least in the initial years such pricing would not recover the cost of the vehicle. Consideration clearly must be given to how any additional costs would be borne. For our purposes here, however, we are investigating whether applications exist that could make use of the required number of vehicles, without regard to cost.

Fleet Vehicles.

EVs are well suited to meet a variety of fleet applications. Fleet vehicles typically have well defined and consistent driving patterns and range requirements, and are centrally refueled.

A recent study of the fleet purchase decision process noted that businesses, utility companies, and government agencies purchase approximately one quarter of all light-duty vehicles sold in the United States each year. (*An Organizational Approach To Understanding the Incorporation of Innovative Technologies Into the Fleet Vehicle Market*, Nesbitt, K.). Given California annual light duty vehicle sales of roughly 1,000,000 per year, this corresponds to a fleet market of about 250,000 vehicles per year. Thus a 10 percent penetration of the fleet market, or 25,000 vehicles per year, would in and of itself be sufficient to meet our estimated “base case” four percent ZEV placement requirement.

Staff has attempted to gather more specific information as to the number of fleet vehicles purchased per year in California by various fleet operators. Information on such purchases is scattered, and to date staff has been unable to obtain precise estimates. The following represents the best available information at this point. Public comment is welcome on these estimates.

Our best information to date indicates that excluding special purpose vehicles such as those used by the California Highway Patrol, the State of California purchases roughly 1,500 passenger cars and light duty trucks per year. Based on 1991 survey results reported by the California Energy Commission, staff estimates that local governments (cities and counties) purchase roughly 14,000 light duty vehicles per year. This total does not include special purpose vehicles such as police cars. Taken together these state and local government fleet sales total more than 15,000 vehicles per year. If electric vehicles could serve one fourth of these governmental applications, it would result in a market of about 3,750 vehicles per year just for state and local public fleets.

Utility companies represent another ideal market. A representative of Southern California Edison testified at the March workshop that EVs already constitute more than 11 percent of their total light duty vehicle fleet, and more than 60 percent of some business units. They plan to add 200 vehicles per year. Staff estimates that by 2003 utility companies statewide could readily absorb 1,000 vehicles per year.

The federal government vehicle fleet and other large institutional fleets also could readily use EVs. Staff does not have quantitative information at this point, but notes that it is reasonable to assume that other fleets could make use of EVs in a manner similar to utilities and governmental fleets.

Commuter Vehicles/Second Cars.

To attempt to quantify the number of households that could reasonably be expected to use an EV for commuting purposes, staff has adapted a methodology used by auto manufacturers. The elements of the calculation are as follows:

Number of owner-occupied households in California with two cars and garage	3,800,000
Percentage of above with annual household income greater than $75,000	x 17%
Result	646,000
Percentage of above with round trip commute of 40 miles or less	x 68%
Result	439,280
Percentage of above that purchase a vehicle in a given year	x 20%
Result	87,856

These assumptions are deliberately somewhat conservative. For example, households with annual income below $75,000 certainly purchase cars, and some fraction of them could be attracted to an EV. Even so, this calculation results in a target population of almost 88,000 households. If 5 percent of these households chose to lease an electric vehicle for commuting or second car purposes, it would result in a market of about 4400 vehicles per year.

City Electric Vehicles.

Ford Motor Company, through its Th!nk subsidiary, plans to market the Th!nk City vehicle beginning in 2001. The market for City Electric Vehicles is largely unexplored. Staff's best estimate at this point is that the market for City EVs would parallel but be somewhat smaller than that noted above for commuter vehicles and second cars.

Neighborhood Electric Vehicles.

The market for neighborhood electric vehicles in California also is unexplored at this point. Proponents have noted that there are large numbers of retirement communities, business campuses, gated communities and other developments that provide a potential niche for this type of vehicle.

Summary

In summary, as the technology has advanced and vehicle makers have adapted to current circumstances, it appears that a wide range of vehicle types will be available in 2003. It now appears that a variety of vehicle types aimed at specialized applications will prevail. In total, staff is confident that sufficient applications exist to absorb the number of vehicles that would be required to be placed in 2003.

7.5 Elements Needed for a Successful EV Market

This section outlines several elements that will be essential in order for the EV market to progress. Before listing these marketing needs, however, it is necessary to understand some of the unique attributes of the EV market that need to be taken into account.

Real vs. Perceived Range Needs.

Many drivers remarked that when they first considered an EV, they had an estimate in mind regarding the portion of their driving that could be accommodated within the available range. After living with the vehicle, however, they learned that their actual driving patterns were less demanding than they had imagined, and therefore they were able to use the EV far more than they had anticipated. Drivers noted that this "mismatch" between perceived and actual range needs is an artificial barrier to more widespread demand for EVs. Public information would help in getting customers beyond this perceived barrier.

Consumer Decisionmaking Regarding Lifecycle Cost.

EVs will have a higher up-front cost, offset by savings over time in fuel cost and maintenance. Consumers generally have shown, however, that they value up front savings more than savings achieved over time, even if from an economic standpoint the alternatives are of equal cost. For example, consumers do not always favor energy-saving improvements that clearly will pay for themselves over time. This behavior, although "irrational" in an economic sense, is real and must be addressed in order to achieve the full EV market potential.

Driving the Vehicle Increases Its Appeal.

Many members of the general public have preconceived notions regarding EVs--they are considered "golf carts" with limited driving appeal. At the March workshop drivers testified that once they had an opportunity to drive an EV, they were "sold". The customer satisfaction attributes noted above (smoothness, quiet, performance, fun to drive) can only be experienced in person. Staff has noted a similar phenomenon in the operation of the EV loan program. Once fleet users have had an opportunity to drive the vehicle their acceptance of its possible application to their fleet is enhanced.

Public Perception of Hybrid Electric Vehicles.

Many members of the public also have inaccurate perceptions of the relative environmental attributes of EVs and hybrid electric vehicles. Staff has noted that in most cases the public assumes that hybrid electric vehicles are as clean as EVs. They thus conclude that hybrids have more appeal because they are just as clean but offer unlimited range and do not need to be recharged. In fact, although the efficiency of hybrid electric vehicles offers CO2 advantages, from a smog standpoint today's hybrids are not as clean as the most advanced conventional vehicles, let alone an EV. For example, the Honda Insight is certified to the ULEV level, while Honda sells an Accord that is certified to the SULEV level.

Risk of New Technology.

EVs feature cutting-edge technology. For some customers, this is a positive benefit. The manufacturer marketing strategies noted above focused on "early adopters" and "techno champs" for that reason. For other customers, however, the introduction of new technology is cause for hesitation. Such customers, who ultimately may be well suited to using EVs, will need additional information and consultation. They also will be very sensitive to any perception that the EV market has no future.

7.5.2 Marketing Needs

Given this backdrop, staff has identified several factors that are critical to the ongoing success of the EV market.

Continuity.

Perhaps the single greatest need is for a smooth, orderly buildup from the current base of activity towards 2003. A great deal of effort has been expended to bring us to where we are today from the standpoint of infrastructure development, dealership training, public outreach, and other factors. At the moment, however, there is a large gap between the completion of the MOA placements and the beginning of the 2003 requirement.

During the 1996 Biennial Review, the transition between the MOA program, which ends in the year 2000, and the ZEV regulation, which begins in 2003, was the subject of much discussion. Some parties argued for specific percentage phase-in requirements for 2000 through 2002. The manufacturers resisted any pre-defined ramp-up requirements, arguing that flexibility was needed to accommodate differing manufacturer technical approaches and development timing. In the end, a flexible approach was adopted. Unfortunately, despite waiting lists for vehicles and other clear evidence that willing customers exist, that flexibility has resulted in only limited product being available at this point.

In most cases, there is no evidence that manufacturers plan to continue to make product available, particularly to the general public, through 2003. On the bright side, Ford is gearing up to market the Think City EV in 2001, and has already begun to run television advertisements. Ford also has indicated that it will continue to produce lead acid Ranger EVs. Toyota has stated that it will continue to produce the RAV4 EV, and is taking fleet orders for next year's production (the current year production is sold out). For the remaining manufacturers, however, staff is not aware at this point of any firm commitment to produce additional vehicles prior to 2003.

Staff is concerned that a "boom and bust" cycle could wipe out the progress that has been made, and create an irreversible impression in the public's mind that EV technology is a thing of the past rather than a preview of the future.

Mainstream Vehicle Platforms.

As noted above, staff recognizes that the choice of vehicle platform was the subject of a great deal of analysis and research by the manufacturers. It is noteworthy, however, that at present there is no four door, five passenger sedan available. In order to achieve ongoing annual market penetration at the required level, staff believes that it will be necessary to have additional vehicle platforms available.

Public Education.

We have noted that EV customers likely will need information above and beyond what is typically required for a vehicle purchase. Topics to be addressed include typical real world range needs and driving patterns, the benefits of a lifecycle cost approach, and the environmental superiority of pure electric vehicles. Customers also are likely to require more extended test drives than are typically offered. Staff notes that the Toyota Prius marketing plan calls for “demonstrator” vehicles to be available to interested customers for an overnight loan. Manufacturers have emphasized demonstration vehicles in their fleet marketing approach for EVs. A similar approach to retail EV sales will likely be necessary.

Market to Retail Customers.

As noted above, several auto manufacturers restricted their sales and marketing efforts to fleet customers only. During the MOA period, this approach had certain advantages, and allowed those manufacturers to limit their training, service and support needs, provide more targeted customer service, and focus on a better defined and more predictable set of driving patterns. In order to achieve the required 2003 placement levels, staff believes that it will be necessary for all manufacturers to market to retail as well as fleet customers.

Competitive Pricing.

Finally, in order for the market to succeed it will be necessary for EVs to be available to customers at prices that are competitive on a lifecycle cost basis to comparable conventional vehicles. A cost estimation methodology is presented in Section 8 of this document. Staff has not yet provided estimates of relative EV and conventional vehicle costs, and will not do so until the public has had a chance to review and comment on the cost estimation methodology and assumptions, and on the work of the Battery Technical Advisory Panel.

Assuming that at least in the short term EV costs will exceed costs for conventional vehicles, it will be necessary to consider some combination of governmental incentives and manufacturer subsidies to close the gap.

8 COST ESTIMATION METHODOLOGY

8.1 Introduction

As noted in the opening discussion of the shared long-term vision, continued reliance on today's technology will not allow us to reach our health based air quality goals. In this vision of the future, the vehicle fleet will produce zero tailpipe emissions, will use fuels with minimal "fuel cycle" emissions, and will be highly energy efficient, with reduced emissions of greenhouse gases. Any discussion of the costs and benefits of ZEV technology must look beyond today's immediate circumstances, and attempt to visualize what is necessary to move towards the desired future. Automakers have had many years to refine and reduce costs for the manufacture of internal combustion engines. Electric drive vehicles are just at the beginning of the cost reduction cycle.

This section presents staff's methodology for calculating comparative lifecycle cost estimates for battery electric vehicles and near-term partial ZEV vehicles (hybrid electric vehicles and SULEV internal combustion engine vehicles). Examples are given which show the application of the methodology for given sets of assumptions. Staff seeks public comment on the methodology and assumptions used, and their application.

The purpose of this section is to document the cost analysis methodology. The example calculations that are provided have been chosen to illustrate a range of possible costs, and are not intended to indicate staff's assessment of likely scenarios. Staff will not present more specific estimates until the public has had a chance to review and comment on the calculation methodology and the assumptions used, and has also had an opportunity to review and comment on the work of the Battery Technical Advisory Panel.

The cost estimates presented here include the cost of the battery, any unique EV or HEV components, fuel, and maintenance for each vehicle type. It should be noted that in order to simplify the calculations and their presentation, this analysis only considers a subset of vehicle operating costs--those expected to vary significantly across vehicle types. Therefore, the estimates reported here are not directly comparable to other reported estimates of lifecycle cost per mile. Our methodology is intended to provide a relative sense of the lifecycle cost difference across different vehicle types, rather than an absolute estimate of operating cost per mile.

Comparative cost per mile ranges are provided for freeway capable battery electric vehicles, city electric vehicles, gasoline-electric power assist hybrid vehicles, and gasoline ICE vehicles. Low speed electric vehicles are discussed qualitatively but no cost per mile figures are generated.

These are the vehicle types that are expected to be available in the 2003 timeframe. Because these vehicles are in production today, more reliable cost information is available for them. Cost information for other advanced vehicles not expected to be in production in 2003 (e.g. fuel cells, or hybrids with all-electric range) generally is far more tentative at this point, and no estimates of such costs are developed in this document.

8.1.1 Previous Analyses

The most recent detailed ARB assessment of electric vehicle operating cost was prepared in 1994 to support that year's Biennial Review. That assessment concluded that "the net present value of the battery and operating cost of an electric vehicle using a high-energy battery (in volume production) can be comparable to the net present value of the cost to operate a conventional compact car." Although certain assumptions are handled differently, from a methodological standpoint the cost calculations in this section follow the approach used in 1994.

Other analyses have also attempted to estimate the lifecycle cost of various vehicle types. A Review of Electric Vehicle Cost Studies: Assumptions, Methodologies, and Results (Lipman, 1999) reviewed eight EV cost studies performed from 1994 to 1999. This report summarized that "The EV cost studies…report somewhat disparate results. All studies conclude that EV costs will be higher than conventional vehicle costs in the near term, but a few studies suggest that EV costs could relatively quickly drop to levels comparable to those of conventional vehicles, particularly on a lifecycle basis. Most studies suggest that EV purchase costs are expected to remain a few to several thousand dollars higher than conventional vehicle costs, with lifecycle costs also remaining somewhat higher. Finally, one study concludes that EV purchase prices are likely to remain much higher than conventional vehicle prices, through 2010".

The report went on to note that "Some of the variation in the reported results of EV manufacturing costs can be explained by considering the vehicle classes, production volumes, and battery types considered in the various analyses. However, aside from these critical study parameters, considerable variation remains in the vehicle purchase price and lifecycle cost estimates reported here. Uncertain parameters that help to account for the remaining differences in cost estimates include the assumed performance of the vehicle…, the cost of the assumed battery type, and costs of accessories and additional equipment needed for the EV".

One more recent analysis, not discussed in the Lipman review, is the Motor Vehicle Lifecycle Cost and Energy-Use Model (Delucchi, 2000), prepared for the Air Resources Board by the Institute of Transportation Studies, University of California, Davis. This model "designs" a vehicle to meet range and performance requirements specified by the modeler, and then calculates the initial retail cost and total lifecycle cost of the designed vehicle. The model uses detailed assessments of vehicle cost and weight, vehicle energy use, and periodic ownership and operating costs. The model calculates the performance and cost of twelve kinds of light-duty motor vehicles. For battery electric vehicles, results are presented for two kinds of vehicles (Ford Escort and Ford Taurus) and four kinds of batteries (lead acid, NiMH Gen2, Li-Ion, and NiMH Gen4).

With regard to initial vehicle cost, in all cases analyzed in the Delucci study the retail cost of the EV is higher than the retail cost of the comparison ICEV Taurus or the comparison ICEV Escort. The report notes that "the higher initial cost of the EV is due mainly to the high cost of the battery". From a lifecycle cost standpoint, one scenario resulted in a lifecycle cost competitive with that of the ICE vehicle. In the other cases analyzed, using this study's methodology, the cost of the battery resulted in a higher EV lifecycle cost.

The existing studies do not provide a consistent framework for assessing and reporting comparative vehicle lifecycle cost, nor do they report similar results, particularly for long term prospects. This lack of consistency underscores the difficulty and uncertainty associated with projecting future costs for evolving technology. That is why in this document we provide examples for a range of possible scenarios.

8.1.2 Methodology

The lifecycle cost analyses used in this report focus on a subset of vehicle operating costs—those costs expected to vary across vehicle types, and to have a significant effect on the total. Thus many other costs are not included, such as the cost of the basic vehicle platform, insurance, or vehicle registration. Because this analysis does not address all aspects of building and operating a vehicle, the estimates developed here are not directly comparable to other reported estimates of lifecycle operating cost per mile.

This simplified analysis takes into account the following costs, aggregated over a ten-year vehicle life:

<u>Battery electric vehicle</u>:
Battery pack cost
EV component cost (incremental cost of unique EV components other than the battery)
Fuel cost (electricity)
Maintenance cost

<u>Power assist hybrid electric vehicle</u>:
Battery pack cost
HEV component cost (incremental cost of unique HEV components other than the battery)
Fuel cost (gasoline)
Maintenance cost

<u>Internal combustion engine vehicle</u>:
Fuel cost (gasoline)
Maintenance cost

The identified costs are totaled over the ten-year life of the vehicle, then discounted back to present dollars. This discounted sum is then divided by the number of miles traveled to give a net present value cost per mile. In this analysis, we assume 10 year lifetime vehicle mile traveled of roughly 117,000 miles, based on the standard ARB emission inventory estimate, for all vehicles other than city EVs. Lifetime vehicle miles traveled for city EVs is assumed to be 75 percent of that for freeway capable vehicles, or about 88,000 miles.

This approach does not take into account possible variations in vehicle range, performance, or other attributes. Rather, all vehicle operating characteristics are expressed in terms of two measures--battery pack capacity (for electric vehicles), and vehicle efficiency.

Even this simplified analysis requires the use of a number of assumptions:

Battery pack capacity
Battery cost per kWh
Battery life
Battery salvage value
Incremental cost of EV components
Incremental cost of HEV components
Price of electricity
Price of gasoline
Battery electric vehicle efficiency
HEV efficiency
ICE vehicle efficiency
Maintenance cost, battery electric vehicle
Maintenance cost, HEV
Maintenance cost, gasoline vehicle
Inflation rate
Discount rate

Calculations are provided for several examples, which incorporate different possible values for the various assumptions. We also discuss the relative importance of the various cost factors.

8.2 Freeway Capable Battery Electric Vehicles

This section presents a cost calculation methodology for freeway capable battery electric vehicles.

8.2.1 Assumptions

As noted above, a number of assumptions must be made in order to perform cost calculations. Staff has identified a plausible range of values for each assumption. The values chosen are intended to “bracket” the range of plausible scenarios--from near term, low volume production with current technology, to long term, high volume production with continued technical improvement. The resulting range of values is shown in Table 8-1, and each assumption is further discussed below.

Table 8-1

Freeway Capable Battery Electric Vehicle Assumptions

Assumption	Range of Values
Battery pack capacity	10-40 kWh
Battery cost	$100-$400 per kWh
Battery life	6-10 years
Battery salvage value	$25-$100 per kWh
Vehicle efficiency	0.18-0.8 kWh per mile
Price of electricity	$0.04-$0.15 per kWh
EV component cost	$10,000-(-$3000)
Maintenance cost	$0.02-$0.05 per mile
Inflation rate	3 percent
Discount rate	8 percent

<u>Battery Pack Capacity</u>

Battery pack capacity is expected to range between 10 and 40 kWh. The lower end of this range represents a highly efficient, low cost commuter car concept. The upper end of the range represents pack capacity for a minivan type vehicle.

<u>Battery Cost Per kWh</u>

Battery pack cost is assumed to range between $100 and $400 per kWh. This range is intentionally broad and is intended to capture long term high volume lead acid or advanced battery costs at one extreme, and near-term advanced battery costs at the other. After public review and comment, the work of the Battery Technical Advisory Panel will be used to help narrow these estimates and choose the most likely cost assumptions for various timeframes and production volumes.

In this analysis, the battery cost represents the cost of the battery pack to the vehicle manufacturer. Thus it is intended to include all equipment necessary to integrate battery modules into a complete pack.

Battery Pack Life

Battery life has a significant effect on lifecycle cost. Battery pack life is assumed to vary between 6 and 10 years.

Because the assumed life of the vehicle is 10 years, some allowance must be made to account for unused battery life at the end of the 10 year period. For example, if battery life is 6 years, and a new pack is installed in year 7, at the end of year 10 the pack still has 2 years of useful life. In such instances we increase the "salvage value" in year 10 to account for the remaining battery life. For instance, if the cost of a 6 year battery pack is $6,000, and at the end of year 10 the pack has two years of useful life remaining, we add one-third of the battery pack cost, or $2,000, to the salvage value of the battery in year 10.

Once again, following public review and comment the work of the Battery Technical Advisory Panel will be used to further refine these estimates.

Battery Pack Salvage Value

Staff assumes that the salvage value for EV batteries will range between $25 and $100 per kWh. This amount does not include the credit for remaining battery life discussed above, but rather covers the value of the battery for secondary uses.

Batteries for electric vehicles generally are considered to have reached the end of their useful life when their capacity has dropped by 20 percent. Staff notes that for NiMH batteries, even a 30 percent reduction in capacity would still allow vehicles to have adequate range for many applications.

However "useful life" is defined, it is clear that a somewhat depleted EV battery still has significant capacity available for use in less-demanding applications. Battery manufacturers and utility companies are investigating possible secondary markets for used vehicle batteries, which generally involve supplying power in remote or distributed locations where the long life of advanced batteries could provide a significant maintenance cost advantage. A secondary market that provides a salvage value for vehicle batteries will effectively reduce the battery cost.

EV Component Cost

The cost of EV components is assumed to range from $10,000 to -$3,000. By "EV components" we mean the added cost of components unique to an electric vehicle (e.g. electric motor and drivetrain, power control electronics) minus the cost of components unique to a gasoline vehicle that are not needed for a battery electric vehicle (e.g. internal combustion engine, fuel tank, transmission). This incremental cost is highly dependent on production volume and can be either positive or negative, depending on whether the necessary changes add or subtract net cost from the overall vehicle.

The “baseline cost” for a gasoline ICE vehicle is assumed to include the cost of any modifications necessary to achieve PZEV certification (e.g. SULEV tailpipe emissions, zero evaporative emissions). Therefore the relative EV component cost is calculated against that base.

For large volume production, staff expects that the only significant capital cost differential between a battery electric vehicle and an internal combustion vehicle will be the cost of the battery pack. In other words, the rest of a battery electric vehicle, aside from the battery pack, is assumed to cost the same as a comparable internal combustion engine vehicle. Staff believes that this assumption is reasonable given volume production. We recognize that at 2003 production levels, full cost equivalence is not yet likely.

In our site visits, auto manufacturers generally maintained that due to the need for additional components (e.g. electric power steering, electric heating and air conditioning, regenerative brakes) the non-battery portion of an electric vehicle was likely to always have some cost premium. Several manufacturers also stated, however, that in volume production such a premium would be small relative to the extra cost of the battery.

<u>Vehicle Efficiency</u>

Electric vehicles are more efficient than their ICE counterparts. This will result in energy and cost savings during vehicle operation. Vehicle efficiency for freeway capable EVs is assumed to vary between 0.18 and 0.8 kWh per mile. Once again this range is intentionally broad, and is intended to capture hyper-efficient advanced vehicles at one extreme and near term large vehicles such as minivans at the other.

Different types, sizes and designs of electric vehicles operate with very different levels of efficiency. Looking at just one source of data, according to a DOE-funded EV test program, EVAmerica, the operating efficiency of present-day EVs ranges from .248 (EV1 PbA) to .432 (RAV 4 EV) AC kWh per mile. Electric pickup truck test results were from .470 to .794 AC kWh per mile, while the EPIC van demonstrated .784 AC kWh per mile. In addition, in real world driving the energy used is affected by driving patterns.

<u>Electricity Price</u>

Staff assumes that the price of electricity for EV charging will range between $0.04 and $0.15 per kWh. The lower number represents discounted off-peak charging. Staff recognizes that higher rates exist for worst case on-peak charging, but believes that it is unlikely that significant EV charging will take place at such rates.

In general, electric vehicles that charge with off-peak power have a fuel cost advantage over gasoline fueled vehicles. Off-peak electricity is cheaper than gasoline from an energy content standpoint, and electric vehicles use their energy very efficiently. The size of the fuel cost differential between electric and gasoline vehicles will vary according to the relative fuel prices.

The electricity prices used in this analysis exclude taxes. Taxes are likewise excluded from gasoline prices in that portion of the analysis. This approach is taken because taxes on electricity and gasoline are “transfer payments” used for other social purposes and are not truly a part of the cost of the product. (In economic terms, transfer payments are transfers of money or economic value from one party to another without an exchange of goods or services in return, and are not included within costs or benefits.) In Sacramento, which staff believes is representative of the rest of the state, electricity is assessed a 7.5 percent local use tax plus a $0.02 per kWh state surcharge.

Consumers, of course, pay fuel prices that include tax. Thus in assessing the cost faced by a driver and its effect on a purchase or lease decision, the full price with tax included should be used. That is not the case for this current calculation, which is only looking at the actual cost of operating the vehicle.

Maintenance Cost

EV Maintenance cost is expected to range between $0.02 and $0.05 per mile. Due to the different technologies employed, maintenance costs for electric vehicles may differ from those for gasoline vehicles. Several of the studies mentioned in Section 8.1.1 above have attempted to estimate electric vehicle maintenance costs. The range used here is extrapolated from estimates reported in previous studies. Based upon those studies, in this analysis staff assumes that EV maintenance costs will be 25 percent less than ICE maintenance costs. This estimate takes into account the fact that EV tires, which are optimized for low rolling resistance, are more expensive.

Inflation Rate

Annual inflation is assumed to be 3 percent. Ongoing costs such as maintenance and fuel can be expected to increase over time with inflation. Staff is not aware of information that would justify assigning separate inflation rates to the different categories. Therefore a single rate is assumed to apply to all future costs, other than battery pack replacement and battery pack salvage value. Because staff expects battery costs to decline over time, these costs are not inflated.

Discount Rate

The assumed discount rate is 8 percent. The rationale for using a discount rate when considering the value of future costs and benefits is discussed in A Guide for Reviewing Environmental Policy Studies—A Handbook for the California Environmental Protection Agency (M Cubed, 1994). This report notes that "A discount rate is used to calculate the present discounted value of future benefits and costs….The farther in the future benefits are received, the less value they have compared to receiving the same benefits today. The discount rate reflects the time value of money and the riskiness associated with future benefits and costs."

The higher the discount rate, the lower the value, in today's dollars, of costs or payments which occur in future years. Battery electric vehicles typically will have higher initial costs, offset by fuel cost savings over a period of years. Therefore the discount rate used will affect their lifecycle cost relative to internal combustion vehicles, which have lower initial costs but higher fuel costs over time.

The Cal/EPA guidelines for economic analysis recommend that the discount rate used in an analysis should equal "the interest rate on United States Treasury Securities with a maturity that most closely approximates the project [time] horizon, plus two percent." In this instance, the time horizon of the cost analysis is ten years. Therefore according to the Cal/EPA guidelines the resulting discount rate should equal the current interest rate on 10-year Treasury Securities (around 6 percent) plus 2 percent, or 8 percent total.

The discount rates used here are assumed to include inflation. In other words, a nominal discount rate of 8 percent, as used here, equates to a "real" discount rate of 5 percent given the assumed inflation rate of 3 percent.

Relative Significance of Various Factors

Staff has performed a limited "sensitivity analysis" to identify how changes in the various assumptions affect the net present value cost per mile.

Assuming that vehicle performance is held constant, vehicle efficiency has the greatest impact on net present value cost per mile. This is because increased vehicle efficiency allows the use of a smaller battery pack to achieve a given range, and also results in lower fuel costs. For example, a fifty- percent increase in vehicle efficiency, if used to reduce battery pack size by fifty percent, results in nearly a 50 percent reduction in net present value cost per mile. (The exact magnitude of the change varies according to the starting assumptions used). This example does not consider "second-order" effects, such as the further increase in range made possible by a lighter vehicle weight, which would allow a still smaller battery pack. Such iterative improvements would increase the overall benefit of efficiency gains.

The parameters associated with battery cost also have a significant impact. For example, a 50 percent increase or decrease in battery cost results in roughly a 30 percent increase or decrease in the net present value cost per mile. Battery life also is important. Increasing the assumed battery life from 6 to 9 years results in about a 20 percent reduction in net present value cost per mile, while decreasing assumed life from 6 to 3 years increases net present value cost per mile by more than 70 percent.

The only other factor with a significant effect is EV component cost. Increasing or decreasing the assumed EV component cost by $3,000 results in about a 20 percent change in net present value cost per mile.

Maintenance cost has an intermediate impact. A 50 percent increase or decrease in assumed maintenance cost results in roughly a 10 percent corresponding change in net present value cost per mile.

The remaining parameters all have a relatively minor impact. A 50 percent change in battery salvage value, electricity cost, inflation rate, or discount rate each result in about a 5 percent change in net present value cost per mile.

8.2.2 Examples of Cost Calculations

This section illustrates the application of our proposed cost calculation methodology. Two sets of assumptions are shown in Table 8-2 below, to illustrate the range of possible scenarios. Example 1 can be thought of as generally including assumptions that work towards reduced cost, while example 2 includes assumptions that result in higher cost.

Staff again wishes to emphasize that these examples are intended to allow the reader to follow and verify the staff methodology. They should not be interpreted as staff “predictions” of likely cost outcomes. Staff will not provide specific estimates until the public has had an opportunity to review and comment on the cost calculation methodology and the range of assumptions.

Table 8-2

**Freeway Capable Battery Electric Vehicle
Assumptions for Examples of Cost Calculations**

Assumption	Example 1	Example 2
Battery pack capacity	25 kWh	29 kWh
Battery cost	$250 per kWh	$400 per kWh
Battery life	10 years	6 years
Battery salvage value	$70 per kWh	$40 per kWh
Vehicle efficiency	0.2 kWh per mile	0.4 kWh per mile
Price of electricity	$0.05 per kWh	$0.05 per kWh
EV component cost	$0	$3,000
Maintenance cost	$0.03 per mile	$0.03 per mile
Inflation rate	3 percent	3 percent
Discount rate	8 percent	8 percent

Tables 8-3 and 8-4 which follow show the details of the calculations, given these assumptions.

Table 8-3

**Freeway Capable Battery Electric Vehicle
Net Present Value Calculation, Example 1**

Discount rate:			8%				
Battery cost, $ per kWh:			$250				
Pack capacity, kWh:			25				
Pack cost:			$6,250				
Pack life, years:			10				
Pack salvage value, $ per kWh:			$70				
Electricity cost, $ per kWh:			$0.05				
EV component cost:			$0				
kWh per mile:			0.200				
Maintenance, $ per mile:			$0.03				
Inflation rate:			1.03				
Year	Mileage	Pack Cost	Comp.	E. Price.	Fuel	Maint.	Total
0	0	$6,250	$0				$6,250
1	13,352	$0	$0	$0.050	$134	$401	$534
2	12,948	$0	$0	$0.052	$133	$400	$533
3	12,556	$0	$0	$0.053	$133	$400	$533
4	12,176	$0	$0	$0.055	$133	$399	$532
5	11,808	$0	$0	$0.056	$133	$399	$532
6	11,450	$0	$0	$0.058	$133	$398	$531
7	11,104	$0	$0	$0.060	$133	$398	$530
8	10,768	$0	$0	$0.061	$132	$397	$530
9	10,442	$0	$0	$0.063	$132	$397	$529
10	10,126	-$1,750	$0	$0.065	$132	$396	-$1,222
Total	116,730	$4,500	$0		$1,328	$3,985	$9,813
NPV of total		$5,439	$0		$892	$2,676	$9,007
$ per mile		$0.047	$0.000		$0.008	$0.023	$0.077

Table 8-4

**Freeway Capable Battery Electric Vehicle
Net Present Value Calculation, Example 2**

Discount rate:			8%				
Battery cost, $ per kWh:			$400				
Pack capacity, kWh:			29				
Pack cost:			$11,600				
Pack life, years:			6				
Pack salvage value, $ per kWh:			$40				
Electricity cost, $ per kWh:			$0.05				
EV component cost:			$3,000				
kWh per mile:			0.400				
Maintenance, $ per mile:			$0.03				
Inflation rate:			1.03				
Year	Mileage	Pack Cost	Comp.	E. Price	Fuel	Maint.	Total
0	0	$11,600	$3,000				$14,600
1	13,352	$0	$0	$0.050	$267	$401	$668
2	12,948	$0	$0	$0.052	$267	$400	$667
3	12,556	$0	$0	$0.053	$266	$400	$666
4	12,176	$0	$0	$0.055	$266	$399	$665
5	11,808	$0	$0	$0.056	$266	$399	$665
6	11,450	$10,440	$0	$0.058	$265	$398	$11,104
7	11,104	$0	$0	$0.060	$265	$398	$663
8	10,768	$0	$0	$0.061	$265	$397	$662
9	10,442	$0	$0	$0.063	$265	$397	$661
10	10,126	-$4,640	$0	$0.065	$264	$396	-$3,979
Total	116,730	$17,400	$3,000		$2,656	$3,985	$27,041
NPV of total		$16,030	$3,000		$1,784	$2,676	$23,489
$ per mile		$0.137	$0.026		$0.015	$0.023	$0.201

8.3 City Electric Vehicles

The cost calculations for city electric vehicles, and the relative effect of the different parameters, are similar to those for freeway capable electric vehicles.

8.3.1 Assumptions

The range of values used for some assumptions (battery pack capacity, vehicle efficiency, EV component cost, and maintenance cost) is reduced due to the smaller size of the vehicle. Table 8-5 below shows the range of values used for city EV calculations.

Table 8-5

City Electric Vehicle Assumptions

Assumption	Range of Values
Battery pack capacity	8-12 kWh
Battery cost	$100-$400 per kWh
Battery life	6-10 years
Battery salvage value	$25-$100 per kWh
Vehicle efficiency	0.15-0.3 kWh per mile
Price of electricity	$0.04-$0.15 per kWh
EV component cost	$6000-(-$2000)
Maintenance cost	$0.01-$0.04 per mile
Inflation rate	3 percent
Discount rate	8 percent

Differences from the assumptions used for freeway capable vehicles are described below. In addition to these changes in standard assumptions, please note that in the city EV calculations the lifetime vehicle miles traveled is assumed to be 75 percent of that for the other vehicles, or about 87,000 miles over ten years.

Battery Pack Capacity

Battery pack capacity is expected to range between 8 and 12 kWh. This represents the typical battery pack size used on current city EVs. Staff notes that city EVs may have a greater likelihood of using lead acid batteries.

EV Component Cost

The cost of EV components is assumed to range from $6,000 to -$2000. Because these vehicles are smaller, lighter and less expensive than Freeway capable vehicles the range of EV component cost is assumed to be smaller.

Vehicle Efficiency

Vehicle efficiency for city EVs is assumed to vary between 0.15 and 0.3 kWh per mile. Due to their lighter weight these vehicles are assumed to be somewhat more efficient overall than Freeway capable EVs, and to not exhibit the same range of variation.

Maintenance Cost

City EV maintenance cost is expected to range between $0.01 and $0.04 per mile, somewhat less than for freeway capable EVs. This reduction is due to the smaller size and weight of the vehicles.

8.3.2 Examples of Cost Calculations

This section illustrates the application of our proposed cost calculation methodology for city electric vehicles. As was done for Freeway capable vehicles, two example calculations are provided. The assumptions used are shown in Table 8-6 below. Once again, example 1 can be thought of as generally including assumptions that work towards reduced cost, while example 2 includes assumptions that result in higher cost.

These examples are intended to allow the reader to follow and verify the staff methodology. They should not be interpreted as staff predictions of likely cost outcomes. Staff will not provide specific estimates until the public has had an opportunity to review and comment on the cost calculation methodology and the range of assumptions.

Table 8-6

City Electric Vehicle
Assumptions for Examples of Cost Calculations

Assumption	Example 1	Example 2
Battery pack capacity	8 kWh	12 kWh
Battery cost	$250 per kWh	$400 per kWh
Battery life	10 years	6 years
Battery salvage value	$70 per kWh	$40 per kWh
Vehicle efficiency	0.15 kWh per mile	0.3 kWh per mile
Price of electricity	$0.05 per kWh	$0.05 per kWh
EV component cost	$0	$3,000
Maintenance cost	$0.02 per mile	$0.02 per mile
Inflation rate	3 percent	3 percent
Discount rate	8 percent	8 percent

Tables 8-7 and 8-8 show the details of the calculations for these assumptions.

Table 8-7

City Electric Vehicle
Net Present Value Calculation, Example 1

Discount Rate			8%				
Battery cost, $ per kWh:			$250				
Pack capacity, kWh:			8				
Pack cost:			$2,000				
Pack life, years:			10				
Pack salvage value, $ per kWh:			$70				
Electricity cost, $ per kWh:			$0.05				
EV component cost:			$0				
kWh per mile:			0.150				
Maintenance, $ per mile:			$0.02				
Inflation rate:			1.03				
Year	Mileage	Pack Cost	Comp.	Elect.	Fuel	Maint.	Total
0	0	$2,000	$0				$2,000
1	10,014	$0	$0	$0.050	$75	$200	$275
2	9,711	$0	$0	$0.052	$75	$200	$275
3	9,417	$0	$0	$0.053	$75	$200	$275
4	9,132	$0	$0	$0.055	$75	$200	$274
5	8,856	$0	$0	$0.056	$75	$199	$274
6	8,588	$0	$0	$0.058	$75	$199	$274
7	8,328	$0	$0	$0.060	$75	$199	$273
8	8,076	$0	$0	$0.061	$74	$199	$273
9	7,832	$0	$0	$0.063	$74	$198	$273
10	7,595	-$560	$0	$0.065	$74	$198	-$287
Total	87,548	$1,440	$0		$747	$1,992	$4,179
NPV of total		$1,741	$0		$502	$1,338	$3,580
$ per mile		$0.020	$0.000		$0.006	$0.015	$0.041

Table 8-8

City Electric Vehicle
Net Present Value Calculation, Example 2

Discount Rate	8%
Battery cost, $ per kWh:	$400
Pack capacity, kWh:	12
Pack cost:	$4,800
Pack life, years:	6
Pack salvage value, $ per kWh:	$40
Electricity cost, $ per kWh:	$0.05
EV component cost:	$3,000
kWh per mile:	0.300
Maintenance, $ per mile:	$0.02
Inflation rate:	1.03

Year	Mileage	Pack Cost	Comp.	Elect.	Fuel	Maint.	Total
0	0	$4,800	$3,000				$7,800
1	10,014	$0	$0	$0.050	$150	$200	$350
2	9,711	$0	$0	$0.052	$150	$200	$350
3	9,417	$0	$0	$0.053	$150	$200	$350
4	9,132	$0	$0	$0.055	$150	$200	$349
5	8,856	$0	$0	$0.056	$150	$199	$349
6	8,588	$4,320	$0	$0.058	$149	$199	$4,668
7	8,328	$0	$0	$0.060	$149	$199	$348
8	8,076	$0	$0	$0.061	$149	$199	$348
9	7,832	$0	$0	$0.063	$149	$198	$347
10	7,595	-$2,080	$0	$0.065	$149	$198	-$1,733
Total	87,548	$7,040	$3,000		$1,494	$1,992	$13,527
NPV of total		$6,559	$3,000		$1,003	$1,338	$11,900
$ per mile		$0.075	$0.034		$0.011	$0.015	$0.136

8.4 Low Speed Vehicles

Low speed vehicles are on the market today, at prices of around $7,000. These prices appear to cover the cost of production plus manufacturer profit. Because these vehicles are aimed at entirely different market niches from the other battery electric and PZEV vehicles, there is no need to calculate how their lifecycle cost compares. Therefore staff has not developed cost comparison ranges for low speed vehicles.

8.5 Power Assist Hybrid Electric Vehicles

This section presents cost calculations for power assist hybrid electric vehicles. The methodology is generally the same as was used above for battery electric vehicles, with adjustments as necessary due to the different vehicle technology.

8.5.1 Assumptions

The range of assumptions used to calculate cost ranges for power assist hybrids is shown in Table 8-9 below. Assumptions that change for HEVs are discussed below.

Table 8-9

Power Assist Hybrid Electric Vehicle Assumptions

Assumption	Range of Values
Battery pack capacity	.9-2.5 kWh
Battery cost	$100-$500 per kWh
Battery life	10 years
Battery pack salvage value	$25-$100 per kWh
Vehicle efficiency	40-80 miles per gallon
Price of gasoline	$1.00-$2.00 per gallon (excludes tax)
HEV component cost	$1,000-$5,000
Maintenance cost	$0.03-$0.06 per mile
Inflation rate	3 percent
Discount rate	8 percent

Battery Pack Capacity

The battery packs used in HEVs are much smaller than for battery electric vehicles. Battery pack capacity for power assist hybrid electric vehicles is expected to range between .9 and 2.5 kWh.

Battery Cost Per kWh

Battery cost for hybrid electric vehicles is assumed to range between $100 and $500 per kWh. HEV batteries are likely to be more expensive on a kWh basis than EV batteries. In the near term this will be offset due to the higher production volume for HEV batteries. Because HEVs have very small battery packs, the cost of batteries has a much smaller effect on lifecycle cost than is the case for battery electric vehicles.

Battery Pack Life

Because the duty cycle for a hybrid electric vehicle battery is much less demanding than the duty cycle for a battery in a freeway capable vehicle, the battery is assumed to last for the life of the vehicle. Therefore battery pack life is not relevant for hybrid electric vehicles.

HEV Component Cost

The incremental cost of HEV components is assumed to range between $1,000 and $5,000. By “incremental cost of HEV components” we mean the added cost of components unique to a hybrid electric vehicle (electric motor and drivetrain, power control electronics, etc.). No offsetting savings are assumed, because a hybrid electric vehicle needs all of the components of an ICE vehicle, plus components unique to a hybrid.

Gasoline Price

Because hybrid electric vehicles are more efficient than conventional ICE vehicles, they will have a fuel cost advantage over gasoline fueled vehicles. The size of the cost advantage will vary according to the price of gasoline.

The gasoline prices used in this analysis exclude taxes. As noted above, a similar approach is taken with respect to electricity prices. Federal and state fuel excise taxes currently total $0.363 per gallon. In addition, a sales tax of between 7.25 percent and 8.25 percent is assessed on the total cost of the sale. At current gasoline prices of about $1.70 per gallon, tax included, these taxes account for about $0.50 of the $1.70.

Vehicle Efficiency

Vehicle efficiency is assumed to range between 40 and 80 miles per gallon. As noted above, hybrid electric vehicles are more efficient than conventional ICE vehicles. Therefore their fuel cost will be lower. The magnitude of the fuel cost advantage will vary according to the relative efficiency of the vehicles being compared. The assumed range of energy efficiency used in our comparison is based on the efficiency exhibited by current and proposed hybrid electric vehicles.

Maintenance Cost

Due to the different technologies employed, maintenance costs for hybrid electric vehicles may differ from those for gasoline or battery electric vehicles. Staff is not aware of any specific estimates for hybrid electric vehicles. Because hybrid vehicles employ both a conventional and an electric drive system, staff assumes that maintenance cost for hybrids will be higher than for gasoline or electric vehicles. In the absence of more specific information staff assumes that hybrid electric vehicle maintenance costs will be 25 percent higher than for ICE vehicles.

Inflation Rate and Discount Rate

Staff uses the same inflation rate and discount rate for all vehicle types.

8.5.2 Examples of Cost Calculations

This section illustrates the application of our proposed cost calculation methodology for power assist hybrid electric vehicles. As was the case for battery EVs, two sets of assumptions are shown which help to illustrate the range of possible scenarios. The assumptions used in each case are shown in Table 8-10 on the next page. Once again, example 1 can be thought of as generally including assumptions that work towards reduced cost, while example 2 includes assumptions that result in higher cost. These examples are intended to allow the reader to follow and verify the staff methodology. They should not be interpreted as staff predictions of likely cost outcomes. Staff will not provide specific estimates until the public has had an opportunity to review and comment on the cost calculation methodology and the range of assumptions.

Table 8-10

**Power Assist Hybrid Electric Vehicle
Assumptions for Examples of Cost Calculations**

Assumption	**Example 1**	**Example 2**
Battery pack capacity	1 kWh	2 kWh
Battery cost	$250 per kWh	$400 per kWh
Battery pack salvage value	$70 per kWh	$40 per kWh
Vehicle efficiency	60 miles per gallon	40 miles per gallon
Price of gasoline (excluding tax)	$1.30 per gallon	$1.70 per gallon
HEV component cost	$1,000	$3,000
Maintenance cost	$0.05 per mile	$0.05 per mile
Inflation rate	3 percent	3 percent
Discount rate	8 percent	8 percent

Tables 8-11 and 8-12 which follow show the details of the calculation.

Table 8-11

Power Assist Hybrid Electric Vehicle
Net Present Value Calculation, Example 1

Discount rate:	8%
Battery cost, $ per kWh:	$250
Pack capacity, kWh:	1
Pack cost:	$250
Pack salvage value, $ per kWh:	$70
Gasoline, price per gallon	$1.30
HEV component cost:	$1,000
Miles per gallon	60
Maintenance, $ per mile:	$0.05
Inflation rate:	1.03

Year	Mileage	Pack Cost	Comp.	Gas Price	Fuel	Maint.	Total
0	0	$250	$1,000				$1,250
1	13,352	$0	$0	$1.300	$289	$668	$957
2	12,948	$0	$0	$1.339	$289	$688	$977
3	12,556	$0	$0	$1.379	$289	$687	$975
4	12,176	$0	$0	$1.421	$288	$686	$974
5	11,808	$0	$0	$1.463	$288	$685	$973
6	11,450	$0	$0	$1.507	$288	$684	$972
7	11,104	$0	$0	$1.552	$287	$684	$971
8	10,768	$0	$0	$1.599	$287	$683	$970
9	10,442	$0	$0	$1.647	$287	$682	$969
10	10,126	-$70	$0	$1.696	$286	$681	$897
Total	116,730	$180	$1,000		$2,878	$6,827	$10,885
NPV of total		$250	$1,000		$1,932	$4,579	$7,729
$ per mile		$0.002	$0.009		$0.017	$0.039	$0.066

Table 8-12

**Power Assist Hybrid Electric Vehicle
Net Present Value Calculation, Example 2**

Discount rate:	8%
Battery cost, $ per kWh:	$400
Pack capacity, kWh:	2
Pack cost:	$800
Pack salvage value, $ per kWh:	$40
Gasoline, price per gallon	$1.70
HEV component cost:	$3,000
Miles per gallon	40
Maintenance, $ per mile:	$0.05
Inflation rate:	1.03

Year	Mileage	Pack Cost	Comp.	Gas Price	Fuel	Maint.	Total
0	0	$800	$3,000				$3,800
1	13,352	$0	$0	$1.700	$567	$668	$1,235
2	12,948	$0	$0	$1.751	$567	$688	$1,254
3	12,556	$0	$0	$1.804	$566	$687	$1,253
4	12,176	$0	$0	$1.858	$565	$686	$1,251
5	11,808	$0	$0	$1.913	$565	$685	$1,250
6	11,450	$0	$0	$1.971	$564	$684	$1,249
7	11,104	$0	$0	$2.030	$563	$684	$1,247
8	10,768	$0	$0	$2.091	$563	$683	$1,246
9	10,442	$0	$0	$2.154	$562	$682	$1,244
10	10,126	-$80	$0	$2.218	$562	$681	$1,163
Total	116,730	$720	$3,000		$5,645	$6,827	$16,192
NPV of total		$800	$3,000		$3,791	$4,579	$12,133
$ per mile		$0.007	$0.026		$0.032	$0.039	$0.104

8.6 Internal Combustion Engine Vehicles

This section presents cost calculations for internal combustion engine vehicles. The methodology is generally the same as was used above for battery electric and hybrid electric vehicles, with adjustments as necessary due to the different vehicle technology.

8.6.1 Assumptions

The range of assumptions used to calculate cost ranges for ICE vehicles is shown in Table 8-13 below. Areas that are different for ICE vehicles are noted below.

Table 8-13

ICE Vehicle Assumptions

Assumption	Range of Values
Vehicle efficiency	18-40 miles per gallon
Price of gasoline	$1.00-$2.00 per gallon (excludes tax)
Maintenance cost	$0.03-$0.06 per mile
Inflation rate	3 percent
Discount rate	8 percent

The calculations for ICE vehicles do not need to account for battery pack size, battery pack cost, battery life, battery salvage value, or EV/HEV component costs.

Vehicle Efficiency

The assumed range of energy efficiency is based on the range of real world efficiency exhibited by ICE vehicles of a size similar to that of the vehicles under consideration here.

Maintenance Cost

Maintenance cost for ICE vehicles is expected to range between $0.03 and $0.06 per mile. Several of the studies mentioned in Section 8.1.1 above have attempted to estimate ICE vehicle maintenance costs. The range used here is extrapolated from estimates reported in previous studies. Based upon those studies, in this analysis staff assumes that ICE maintenance costs will be 25 percent more than EV maintenance costs.

8.6.2 Examples of Cost Calculations

This section illustrates the application of our proposed cost calculation methodology. Two sets of assumptions are shown, as noted in Table 8-13 below. These examples are intended to allow the reader to follow and verify the staff methodology. They should not be interpreted as staff predictions of likely cost outcomes. Staff will not provide specific estimates until the public has had an opportunity to review and comment on the cost calculation methodology and the range of assumptions.

Table 8-13

ICE Vehicle
Assumptions for Examples of Cost Calculations

Assumption	Example 1	Example 2
Vehicle efficiency	30 miles per gallon	20 miles per gallon
Price of gasoline (excluding tax)	$1.30 per gallon	$1.70 per gallon
Maintenance cost	$0.04 per mile	$0.04 per mile
Inflation rate	3 percent	3 percent
Discount rate	8 percent	8 percent

Tables 8-14 and 8-15 which follow show the details of the calculation.

Table 8-14

ICE Vehicle
Net Present Value Calculation, Example 1

Discount rate:	8%
Gasoline, price per gallon:	$1.30
Miles per gallon:	30
Maintenance, $ per mile:	$0.04
Inflation rate:	1.03

Year	Mileage	Gasoline Price	Fuel	Maintenance	Total
0	0				
1	13,352	$1.300	$579	$534	$1,113
2	12,948	$1.339	$578	$550	$1,128
3	12,556	$1.379	$577	$549	$1,127
4	12,176	$1.421	$577	$549	$1,125
5	11,808	$1.463	$576	$548	$1,124
6	11,450	$1.507	$575	$548	$1,123
7	11,104	$1.552	$575	$547	$1,121
8	10,768	$1.599	$574	$546	$1,120
9	10,442	$1.647	$573	$546	$1,119
10	10,126	$1.696	$573	$545	$1,118
Total	116,730		$5,756	$5,462	$11,217
NPV of total			$3,865	$3,663	$7,528
$ per mile			$0.033	$0.031	$0.064

Table 8-15

ICE Vehicle
Net Present Value Calculation, Example 2

Discount rate:			8%		
Gasoline, price per gallon:			$1.70		
Miles per gallon:			20		
Maintenance, $ per mile:			$0.04		
Inflation rate:			1.03		
Year	Mileage	Gasoline Price	Fuel	Maintenance	Total
0	0				
1	13,352	$1.700	$1,135	$534	$1,669
2	12,948	$1.751	$1,134	$550	$1,684
3	12,556	$1.804	$1,132	$549	$1,682
4	12,176	$1.858	$1,131	$549	$1,680
5	11,808	$1.913	$1,130	$548	$1,678
6	11,450	$1.971	$1,128	$548	$1,676
7	11,104	$2.030	$1,127	$547	$1,674
8	10,768	$2.091	$1,126	$546	$1,672
9	10,442	$2.154	$1,124	$546	$1,670
10	10,126	$2.218	$1,123	$545	$1,668
Total	116,730		$11,290	$5,462	$16,752
NPV of total			$7,581	$3,663	$11,244
$ per mile			$0.065	$0.031	$0.096

8.7 Discussion

This section presents the cost comparison methodology for battery electric vehicles, power assist hybrid vehicles, and ICE vehicles. Examples are provided to illustrate the methodology. No predictions or projections are made at this point regarding likely cost outcomes. Staff will not present more specific estimates until the public has had the opportunity to review and comment on the methodology and assumptions, and on the findings of the Battery Technical Advisory Panel.

9 ENVIRONMENTAL AND ENERGY IMPACT

REDRAFT PENDING

10 CONCLUSION

10.1 A Blueprint for Further Progress

In order to successfully place the vehicles required under the ZEV program regulations, and achieve the resulting long-term air quality and other environmental benefits, several things need to be in place.

First, the technology must have arrived at the point where reliable vehicles are available, with performance characteristics sufficient to meet a range of market applications. Based on the investigation discussed in this report, staff concludes that today's vehicles clearly meet this test. A variety of attractive platforms are available, and these vehicles are in everyday use in many different circumstances across the state. All evidence and testimony points to the fact that those who are using today's vehicles are very pleased with their performance.

Second, market applications must exist that can absorb the necessary number of vehicles. Although this portion of the analysis is necessarily more speculative than the technology review, as reported in the EV Market section staff has confidence that sufficient market applications exist to make use of the required number of vehicles.

Third, the vehicles must be available at prices that are competitive to conventional vehicles on a lifecycle cost basis. Here, staff has not reported conclusions and will not do so until the public has had a chance to review the cost analysis methodology and the findings of the Battery Technical Advisory Panel.

Staff recognizes that at least in the near term battery electric vehicles will be more costly to produce than their conventional counterparts. This is not surprising, given that each incremental step towards more stringent air pollution controls provides additional benefits, but at additional cost. The ZEV program, meanwhile, is not a typical incremental step but rather a visionary approach that will transform our vehicle pollution control strategy and bring with it comprehensive multimedia environmental and energy benefits. Given the sweeping nature of its effects it is reasonable to expect that the program will be more expensive in its early years than other more limited measures.

Various means are available to close this cost gap. Ultimately, the decision as to what costs are reasonable and how they should be borne is a policy matter for the Board to determine.

The above three conditions will help ensure successful implementation of the ZEV regulation. Other factors can ease the transition. As discussed in the EV market section, continuity between today and 2003 is vital. At the moment, however, there is a large gap between the completion of the MOA placements and the beginning of the 2003 requirement.

Finally, there will need to be teamwork among the interested parties who follow the ZEV issue. The auto manufacturers will benefit from the assistance of others. Areas where cooperative efforts would be helpful include the provision of incentives, development of the fleet market, and public education.

10.2 Next Steps

The ARB is committed to working closely with all interested parties to ensure that they have an opportunity to provide comments and suggestions throughout the review process. The key milestones of the review process are as follows:

March 29, 2000	Public Workshop Background Information for the September Review Sacramento
March 30, 2000	Public Workshop Multi-Manufacturer Ownership Arrangements Sacramento
May 31-June 1, 2000	Public Workshop Background Information for the September Review Diamond Bar
August 2000	Staff Report released to the public
September 7, 2000	Board Meeting

Comments are welcome on all aspects of this material. Following the May public workshop and the review of all comments received, staff will make changes as appropriate and release the Staff Report in early August.

By following this process we hope to provide a firm, agreed-upon technical basis for the Board’s policy review and discussion at the September Board meeting.

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